SAE JOURNAL

JANUARY 1949

SAE JOURNAL

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JANUARY

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Bendix Products

BUILDERS OF THE BASICS OF BETTER MOTOR VEHICLES

BENDIX VACUUM-POWER SHIFT

for two-speed axles—smooth, fast, easy!

Here's another control problem solved by Bendix Vacuum-Power! With a Bendix Vacuum-Power chamber on the axle and a "Preselector" control on the instrument panel (or gear shift lever), truck drivers get an easy, positive, fast-acting, *power* shift. A flick of the finger and intake manifold vacuum does the actual work of shifting! Low original and maintenance costs make it your logical choice.

This Bendix Vacuum-Power Shift has proved a worthy companion to Timken-Detroit's great line of 2-speed truck axles, with a record of many years and billions of miles of dependable performance.

*REG. U.S. PAT. OFF.

BENDIX PRODUCTS
DIVISION of Bendix AVIATION CORPORATION
SOUTH BEND 20, INDIANA

To All Members....

The value as well as the privilege of serving as president of this Society is one that cannot be overestimated. I never would have realized before undertaking the task, just how much it could bring to me personally. My travels this year have been very wide, missing only one Section, and have been augmented by quite a number of visits to other societies and scientific bodies on account of the SAE. I don't think there is any better way of meeting people—the most valuable thing about this traveling—and one is able to see the activities in business, aside from the Society, of all the members.

I need not make any remarks about the growth of the Society. The main impression one gets is that we have probably a little more liveliness and ginger than any other technical society with which I have been connected; and it is this spirit that makes this Society so good. Another thing that shows an extremely healthy attitude is that if anybody has a gripe about anything whatever, he sits down with you and talks it out; and no matter what the final answer is, everybody seems to feel that something useful gets done.

I wish to offer as a more personal note, my very heartiest thanks to all of those who have worked not only with me but for the Society's general activities. They have all done a wonderful job and have left me with the comfortable feeling of a remarkable year's experience.

RJSPigott

President's Report for 1948

Growth and expansion characterized the activities in practically every area of SAE operation during 1948.

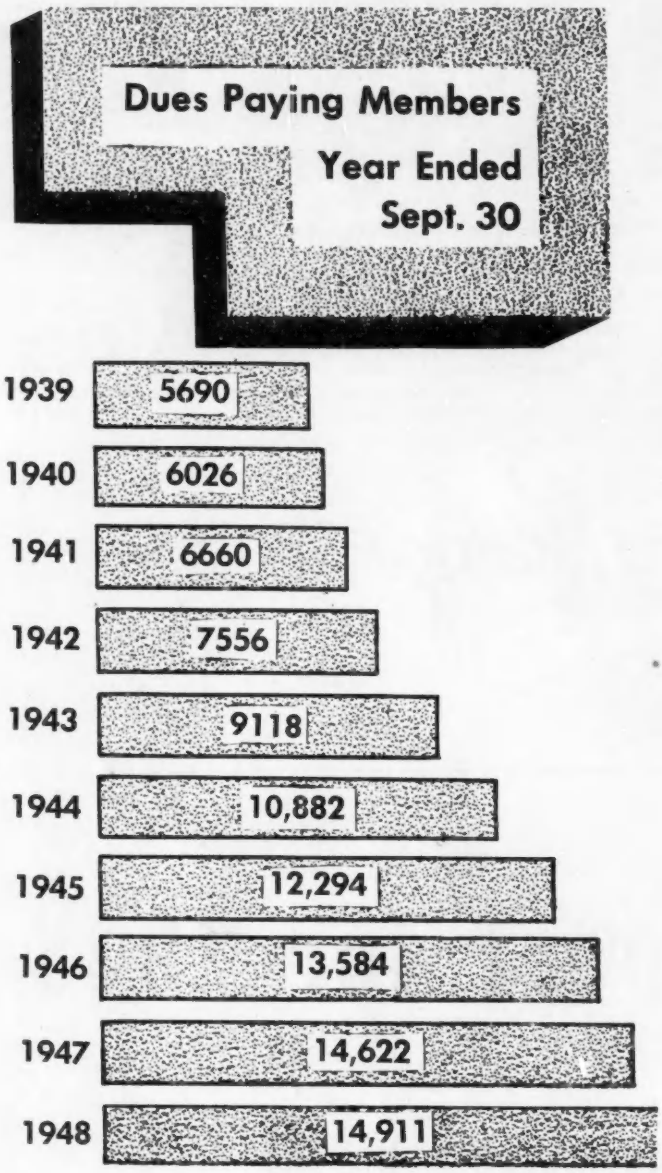
Extensive revisions in the SAE Constitution and By-Laws were completed and approved as recommended by the Constitution Committee and the Advisory Committee to Council.

Membership hit a new high again—for the fourteenth straight year. Enrolled students numbered 70% more than in record-breaking 1947. More technical information went to members through SAE publication channels than in any previous year. Income was in excess of expenditures for the first time in three years. More than 9000 attended the 10 national meetings held in 1948; more than 45,000, the 360 Section meetings. More employers actively used SAE Placement Service facilities than ever before . . . and public relations activities brought SAE forcefully to the attention of industrial executives in scores of specific ways. . . . Technical committees operating under direction of the SAE Technical Board broke important new ground in aeronautic standardization and in construction and industrial machinery areas, and recorded major advances over wide ranges of motor vehicle and metallurgical standardization and engineering reports.

Membership Up for 14th Straight Year

With a total of 14,911 net paid members at the end of the fiscal year, the Society—for the fourteenth consecutive year—reports a net gain in membership. The rate of membership growth has decreased since the close of the war, due in part to the loss of marginal members who entered the Society during the flush war years and in part to a normal tapering off in the flow of applications for membership. This trend, combined with a small loss of membership to be expected as the result of the recent revision in dues, will make it more difficult to show a net increase during the coming year.

The new schedule of dues, which became effective Oct. 1, has received generally favorable acceptance by the membership. Although data are by no means complete, current indications are that comparatively few members will be lost because of the new rates. Basing of dues upon age and elimination of transfer fees have been acclaimed by many as bene-



ficial for the members and the Society.

During the past year 1707 applications for membership have been secured by Section, Group and Activity membership committees and through the cooperation of other members. This figure is approximately 15% below that of the previous fiscal year but well above that of any prewar year. Estimates based upon reports from the individual Sections and Groups indicate that the number of applications will show a moderate increase during the coming year.

Several Constitutional revisions adopted during the past year have concerned membership. Membership in the Society has been limited to individuals, and Affiliate and Departmental memberships have been discontinued; also the requirements for Associate grade of membership have been revised. The By-Laws have been amended to require that a minimum of two SAE member references be named by each candidate for membership, and that candidates submitting less than five member references are subject to such special investigation as may be determined necessary.

Student Progress Swift

Strong growth in Student Enrollment continued during 1947-1948, with approximately 3800 students attending 74 engineering schools affiliated with the Society. This figure marks a 70% growth over the previous fiscal year, which has eclipsed all previous records.

The number of SAE Student Branches increased to 25 and several potential Student Branches have been organized as informal SAE Clubs during the year. Our newest Student Branches to be granted charters by the Council upon recommendation of the Student Committee are located at the University of British Columbia, Illinois Institute of Technology and Parks College of Aeronautical Technology of St. Louis University.

All Student Branches are well launched on their 1948-1949 program. Student officers are receiving helpful cooperation from their faculty advisers and the Student Committees of Sections located in their areas.

Technical Committees Advance on Wide Front

Among the major highlights of the comprehensive program of technical committee activities under the direction of the SAE Technical Board in 1948 have been the aircraft engine and propeller utility parts standardization program carried on in cooperation with the armed services, international cooperation on screw thread and motor vehicle lighting problems, and the development of the first SAE standards for construction and industrial machinery.

The aircraft utility parts program was launched early in 1948 and to date has resulted in the issuance of 45 standards. These standards carry AN numbers and are recognized as the standards of both industry and government. This is not only a unique situation but also an outstanding example of effective cooperation between civilian engineers and the armed services.

Of outstanding importance in the international field is the agreement reached by Canada, Britain and the United States on a unified screw thread practice. Technical negotiations leading up to this agreement were handled by the American Standards Association Sectional Committee B-1 for which the SAE and ASME are sponsors. The American Standard for screw threads is being modified to conform to this agreement and will incorporate new fit classifications providing an allowance or clearance be-

tween internal and external threads. Much of the initial work on these new fits was done in the automotive field where the need for them was most pressing because of production difficulties encountered in high-speed wrenching.

During the past year the Society also participated formally for the first time in the work of the International Organization for Standardization (ISO). An SAE representative attended a meeting of the ISO Committee on Automobiles at the Hague in October. At this meeting, extensive consideration was given to the reconciliation of conflicts in national legal lighting requirements which are militating against international trade in automobiles. Another topic of major importance at this meeting was standards for spark plug threads.

The year just ended was also marked by the issuance of the first SAE standards for construction and industrial machinery. These standards cover drawbars and equipment mounting dimensions for track-type tractors and yardage ratings for bodies. Numerous other standards in this area are under development for issuance during the coming year.

Activity on Aeronautical Material Specifications continued at a high level during the year. A total of 149 new or revised AMS were issued during the year. The use of these specifications continues to expand as their usefulness gains increasing recognition both in industry and the armed services. Development of SAE Standards setting up minimum performance requirements for aircraft equipment has been prosecuted aggressively and 36 specifications in this category have been issued. These specifications are prepared for reference in Technical Standard Orders of the CAA.

In the motor vehicle field, specifications for a new truck-type direction signal and for a school bus warning signal have been developed. New technical information on transmission and axle lubricant usage has been worked up. Studies have been inaugurated on fluids for hydraulic torque converters and on a new 5-W crankcase oil for use in extremely cold climates. Standards for moldings and fasteners, and for locks and keys have been developed. Brake and coolant hose specifications have been revised. The American viewpoint on motor vehicle lighting has been developed for the International Committee on Illumination and a test program comparing American and European headlighting practice is being organized. New standards for suspension springs have been issued as has a nomenclature for commercial vehicles.

In the materials field, additional hardenability bands have been adopted and the hardenability test procedure has been revised. A specification for pearlitic malleables has been made available and the specification for automotive iron castings has been revised and brought up to date. Non-ferrous metal specifications have been reviewed and revised as have shaft ends and Woodruff keys. Cooperation with Army Ordnance has involved advice on testing nomenclature and vehicle mobility under plastic soil conditions.

National Meetings
Sessions
Papers

Year	Number of Meetings	Number of Sessions	Number of Papers
1941	7	64	118
1942	7	52*	102*
1943	9	73	146
1944	10	97	185
1945	**	**	**
1946	11	112	226
1947	11	112	211
1948	10	106	185

*Drop caused by sudden cancellation of Summer Meeting.

**Figures not significant — seven National Meetings cancelled because of Meetings ban by the Government.

Consolidations Mark 1948 Meetings Progress

Reflecting a postwar trend, the 10 national meetings held throughout the country during 1948 were marked by consolidations in which two or more activities merged their complementary interests in a single meeting. Total registration during 1948 was maintained at 9000—the same as during 1947—de-

spite the facts that there was one less meeting; 185 papers were presented as compared with 211 in 1947; and there were 106 sessions instead of 1947's 112.

First example of these combined meetings was the first postwar National Passenger Car and Production Meeting held in March, in Detroit, in which the Passenger Car, Body, and Production Activities participated.

The first National West Coast Meeting held in August, in San Francisco, contributed another convincing demonstration of the benefits of wider participation. In place of the former National West Coast Transportation and Maintenance Meeting sponsored only by the SAE T & M Activity, the scope of this meeting was broadened to include sponsorship also by the Truck and Bus, Fuels and Lubricants, and Diesel Engine Activities. An attendance of over 500 was 30% greater than any past West Coast National T & M Meeting.

Another successful consolidation occurred when the Tractor and Diesel Engine Activities joined their mutual interests in a National Tractor and Diesel Engine Meeting held in Milwaukee in September, and expanded the meeting from two days to three. Result: the largest meeting the SAE has ever held in Milwaukee.

Two combinations were effected in the aviation field. The SAE National Air Transport Engineering Meeting, formerly held in the midwest in December, was consolidated with the spring National Aeronautic Meeting into the SAE National Aeronautic and Air Transport Meeting held in New York in April. Also, the SAE National Personal Aircraft Meeting, initiated in Wichita in May 1947, was combined with the SAE Annual and spring National Aeronautic Meetings.

Again in 1948, the Truck and Bus and Transportation and Maintenance Activities got together to stage a successful SAE National Transportation Meeting, in Philadelphia, in the spring.

An added feature of the 1948 schedule was the SAE International Air Transport Luncheon held on Aug. 2, at the International Air Exhibition, celebrating the formal opening of the New York International Airport. Cooperating with the SAE in the luncheon were the Air Transport Association, Aircraft Industries Association, American Society of Mechanical Engineers, and the Institute of Aeronautical Sciences.

Section Growth Brings 45,000 to 380 Meetings

The Sections and Groups are doing fine jobs in their areas. It has been my pleasure to visit practically all of these units and to see them in action. Local officers and committeemen are cooperating to make each a live and vigorous arm of the Society.

Our 38 Sections and Groups have held more than 360 meetings during the year with a total overall attendance approximating 45,000 SAE members and guests. The majority of the meetings have been devoted to technical subjects of automotive interest. These have been augmented by plant visitations and social events such as play days, golf parties and ladies nights. Several Sections have cooperated as hosts to SAE National Meetings held in their localities.

Sections and Groups have been generous in their cooperation with local SAE Student Branches and steps are being taken by several to provide more activities of direct interest to the Junior members.

Publications Up Volume of Technical Material

The total volume of technical material and information going to members through SAE publication facilities was considerably greater than in the previous year.

Despite strikes and rising costs, SAE Journal published 489 pages of technical feature articles in 1948 as compared to 464 pages in the previous year. Total number of pages in SAE Quarterly Transactions in 1948 was 657 as compared to 693 the previous year. The size of SAE Handbook was increased measurably to record results of expanded standards work by technical committees—and the Special Publications Department distributed a greater volume of meetings papers and technical committee reports than in any previous 12-month period. Arrangements have been made effective for SAE Special Publications Department to act as a channel for distribution of reports released by the Coordinating Research Council. Once received from CRC, these reports are being processed through SAE Special Publications Department in the same manner as are SAE Technical Committee reports.

A larger SAE Roster reflected the Society's new high in membership totals.

Mechanical and cost problems dominated SAE publications operating during 1948. Much of the year was devoted to trying to maintain reasonable publication services on SAE Journal and SAE Quarterly Transactions in the face of a six months' printers strike and a tendency for costs to continue upward. Throughout the strike period, SAE Journal maintained its publication schedule as well as had been possible through a long period of pre-strike slowdowns, but SAE Quarterly Transactions was from one to three months late on three of its four 1948 issues. . . . As the year drew to a close, both publications were back on schedule, with facilities readjusted to make possible a continuance of satisfactory mechanical operations.

SAE Journal, during the year, kept up to date in fulfilling its function of printing promptly technical material from every paper presented before the Society. The high volume of papers approved by Readers Committees for publication in full in SAE Quarterly Transactions finds that publication with

a heavy backlog of unpublished material as the new year starts.

Outstanding in SAE Journal has been the growing completeness and promptness of its coverage of SAE Technical Committee operations.

is the new format of SAE Placement bulletins. These are now second to none in the ease with which they unfold their essential information.

The caliber of applicants, the standing of the companies using the service and the very simplicity with which the service functions are making it increasingly valuable to SAE members and to our growing list of enrolled students.

Executive Interest One Aim of Public Relations

Public Relations efforts throughout the year continued to be focused primarily on activities designed to improve understanding of SAE among general automotive executives, among members and prospective members, and in colleges and universities. These are the major lines of effort set up by the policy-making SAE Public Relations Committee.

Outstanding during the year was the feature article about SAE which appeared in the August issue of "Fortune"; several editorials in leading newspapers (such as the New York Times) speaking favorably of SAE technical work; and continuance, on a limited basis, of letters of appreciation to authors of papers and their associates following a number of meetings.

Specially written articles describing and interpreting SAE technical work or featuring material drawn from SAE papers were stimulated in many leading business and trade publications—as well as in appropriate scientific or automotive sections of leading daily newspapers.... In addition, the regular routine releases to the press of SAE meetings and other SAE activities were carried on as usual.

SAE Placement Service Gets New Look in 1948

Changes resulting from complete review of Placement Service procedures 18 months ago were integrated into the operation of the service during 1948.

The list of prospective employers was analyzed, and the inactive names were eliminated. Then, through determined efforts of Section Placement Chairmen, the active list was again revitalized and built up from 205 to 412 companies which now list their openings with SAE and also make use of its Men Available bulletins.

Some Sections have formed groups of active and qualified members who render personal counselling service to those who desire it. This is a significant broadening of the service.

Another important ingredient in current success

SAE Finances Reverse Two-Year Adverse Trend

Nineteen forty-eight recorded a substantial excess of income over expenditures, reversing the trend of the previous two-year period in which deficits had been incurred. The improved 1948 showing was due in part to full realization of operating economies begun two years ago and increasingly implemented during the interim—and in part to better returns in funds from industry for technical committee services coupled with maintenance of member service income. (Balance Sheet and Operating Statement pages 21 and 22.)

Certain costs over which control is limited are continuing to increase. These include travel and postage rates, printing costs, payroll and rent among the major items. To offset these, higher revenues

BALANCE SHEET

As At September 30, 1948

In Agreement with Haskins & Sells Audit

Assets	
Cash—Unrestricted	$102,587.29
Restricted	13,542,29
Notes & Accounts Receivable—Less Reserves	11,835.93
Securities—Cost Value	426,593.00*
Accrued Interests on Securities	2,799.74
Inventories	1,332.47
Deposits	550.00
Furniture & Fixtures	1,000.00
Deferred Charges & Prepayments	39,602.19
Total Assets	$599,842.91
Liabilities & Reserves	
Accounts Payable	$ 23,450.31
Member Dues Received in Advance	38,586.35
Deferred Credits to Income:	
Industrial Income for Technical Board Services	22,960.00
Others	22,505.78
Medals & Awards Reserves	10,280.97
Reserve for Retirement Plan Contributions	11,200.31
General Reserve	470,859.19
Total Liabilities & Reserves	$599,842.91
Accounts Receivable—Member Dues September 30, 1948	$ 315.00

* Book Value (Quoted Market or Redemption Value—9/30/48—$415,765.93)

INCOME AND EXPENSE

Twelve Months Ending September 30, 1948

In Agreement with Haskins & Sells Audit

Income

Membership		
Dues Earned	$183,173.51	
Subscriptions Earned	82,657.49	
Initiation Fees	29,014.25	
Miscellaneous Membership Income	1,287.38	$296,132.63
Publications		
Journal Sales	15,765.40	
Journal Advertising	300,917.50	
Handbook Sales—1946 & 47	7,531.38	
Handbook Sales—1948	6,218.75	
Handbook Advertising	13,650.00	
Transactions Sales—1946 & Prior	478.00	
Transactions Sales—1947	5,265.50	
Transactions Sales—1948	15,273.75	
Aeronautical Publications	20,245.09	
Special Publications	45,457.39	
Miscellaneous Publications	6,119.30	436,922.06
National Meetings		
Guest Registrations & Papers Sold at Meetings	8,493.95	
Dinners	31,015.25	
Displays	13,343.00	
Summer Meeting	6,708.00	59,560.20
Interest & Discount		
Interest Earned	9,123.32	
Discount Earned	151.51	9,274.83
Total Member Service Income		$801,889.72
Industrial Income for Technical Board Services—Exclusive of $22,960 Deferred		135,791.00
Total Income		$937,680.72

Expenses

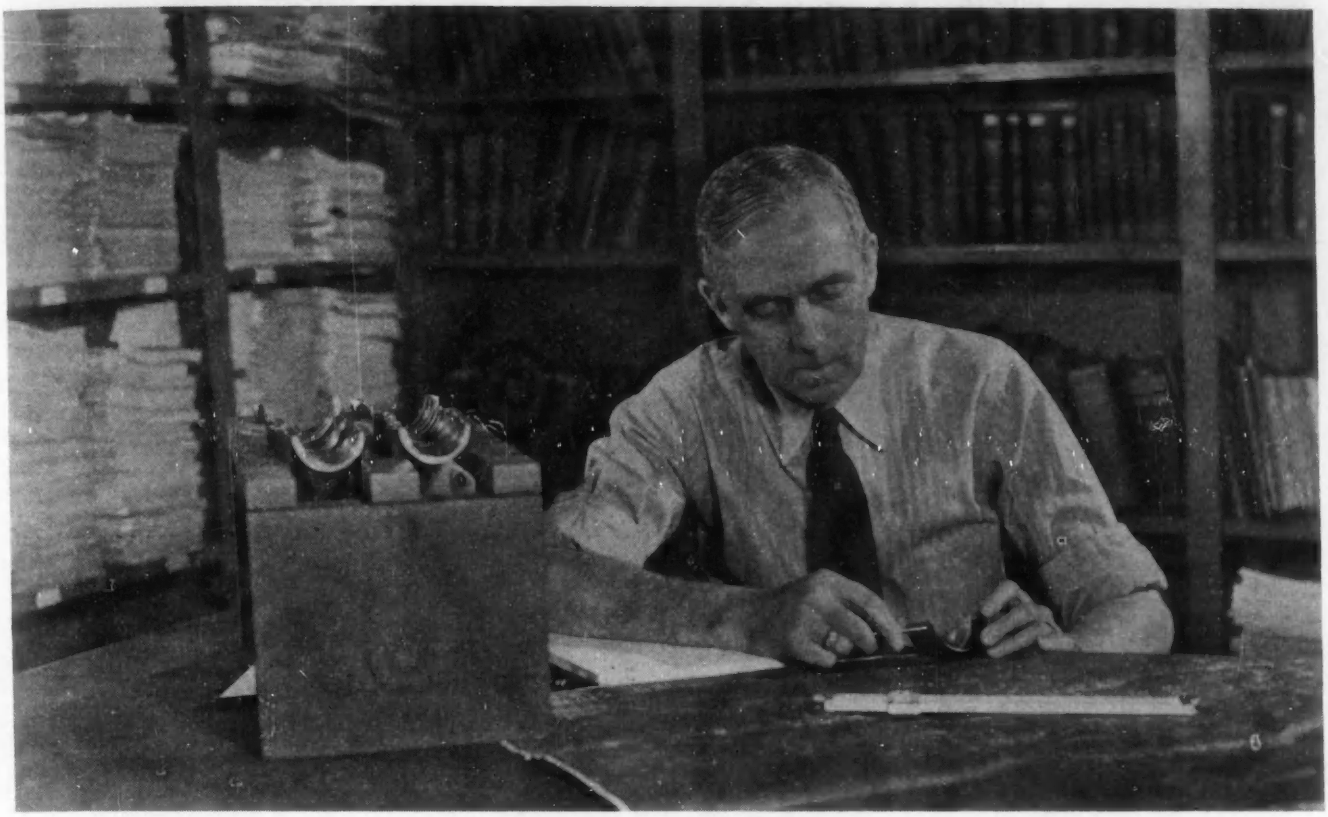
Sections & Membership		
Sections & Student Branches	$ 12,937.11	
Section Appropriations & Dues	49,662.50	
Membership	21,944.20	
West Coast Office	14,951.74	
Miscellaneous Membership Expense	6,974.01	$106,469.56
Pro-Rated Administrative Expense (15.1%)		27,301.25
		133,770.81
Publications		
Journal Editorial	98,524.77	
Journal Advertising	130,559.02	
Handbook Editorial—1947	364.05	
Handbook Editorial—1948	41,396.75	
Handbook Advertising	3,053.25	
Transactions—1946 & Prior	52.85	
Transactions—1947	7,594.93	
Transactions—1948	31,610.42	
Aeronautical Publications	12,644.89	
Special Publications	32,460.68	
Miscellaneous Publications	18,554.90	376,816.51
Pro-Rated Administrative Expense (53.4%)		96,548.79
		473,365.30
National Meetings		
Department Expense	29,108.78	
Cost of Registrations and Papers	3,487.04	
Meetings	21,971.89	
Dinners	26,956.86	
Displays	4,552.73	
Awards	485.18	86,562.48
Pro-Rated Administrative Expense (12.2%)		22,057.96
		108,620.44
Total Member Services Expenses		$715,756.55
Technical Board Services		
Technical Committee Operations	$103,291.07	
CRC Appropriation	27,500.00	
Miscellaneous Expense	5,000.42	135,791.49
Pro-Rated Administrative Expense (19.3%)		34,894.97
		170,686.46
Total Direct Expenses	705,640.04	
Total Administrative Expenses	180,802.97	
Total Expenses		886,443.01
Net Unexpended Income		51,237.71
Total Income		$937,680.72

are anticipated from revised dues schedules and another successful year is expected.

This year some 16 prominent SAE members have carried to industry the message of the SAE Technical Board program. As a result, the budget for industrial support was actually exceeded by a small margin. This excess will be used to carry the program in the early months of the new year, making it unnecessary to call upon membership funds to the extent that has prevailed in the past.

The Finance Committee has long desired to get this technical work on a financially sound footing and did not feel that this excess should be used to make up past deficits. It has, therefore, been specifically ear-marked for the carrying on of the Technical Committee Activities.

In the Member Service area the situation is equally satisfactory and, if economic conditions hold, the Society should once again achieve a reserve position that is adequate and in accord with accepted practice for financial operations of this size.



Stanwood W. Sparrow
...President for 1949

STANWOOD W. SPARROW has been in automotive engineering work ever since he got his B.S. from Worcester Polytechnic Institute back in 1911. He looks like a scientist, acts like an engineer, and is generally regarded as one of the industry's best intellects.

His first job was at Stevens-Duryea in Chicopee Falls, Mass. There he was from 1911 to 1914, "being 1 month in repair shop, 1 year in drafting room, and about 1¾ years in experimental department"—according to his application for membership in SAE, which arrived in 1917 when he had become assistant chief draftsman at the Metz Co. in Waltham, Mass.

After a brief period of general engineering work with Robert Pollack Co., he went to the National Bureau of Standards. His first work there was in the newly constructed altitude chambers and was concerned chiefly with tests of the Liberty and Hispano-Suiza engines of World War I. Later he became chief of the Automotive Powerplant Section. While at the Bureau, he was connected with numerous projects of the National Advisory Committee for Aeronautics, which were carried on at the Bureau under the authorization of the NACA.

He went to Studebaker in 1927 and has been at South Bend ever since. He has built a national reputation—first as one of the top-flight engine and research experts of the industry and, later, as an engineering executive peculiarly capable of getting along with others in business.

Gradually expanding from his original engine research assignments at Studebaker, Sparrow went on to become chief research engineer, the post which he held when World War II broke out.

During the war, devoting practically his entire time to Studebaker's aviation project, which consisted of building the Wright Cyclone engine, he shouldered vast, new technical and personnel responsibilities which made him an important element in a highly successful operation. Now he is vice-president of engineering.

The new SAE president is a man who knows his own mind, makes it up **after** he gets the facts, takes an active interest in any and every phase of SAE operation. He has almost a genius for getting into the facts of a subordinate's or associate's operation, injecting specific ideas and suggestions, and yet leaving with the man in charge a full sense of not having been interfered with. . . . "Dynamic cooperation," one recipient of Sparrow's interest calls it—or, less formally, "mighty pleasant needling."

Sparrow is a bachelor, drives his automobiles at a good pace, collects miniature elephants and miniature swords. . . . He has contributed regularly to automotive technical literature; never wrote a paper for SAE that wasn't overwhelmingly approved for publication in full. He has served on almost every kind of SAE committee.

He has been an SAE Councilor; a member of the SAE Technical Board; chairman of the Washington Section; and served several years as chairman of the Publication Committee, in the affairs of which he still takes a deep personal interest. . . . He was born in Middleborough, Mass. in 1888.

HUSTED

COUNCIL

PIGOTT

FINK

HOVGARD

BACHMAN

FRUDDEN

Completing the 1948-1949 term as councilors are E. E. Husted (top left), Titeflex, Inc.; F. W. Fink, Consolidated Vultee Aircraft Corp.; P. E. Hovgard. B. B. Bachman, Autocar Co., serves again as treasurer. C. E. Frudden, Allis-Chalmers Mfg. Co., and R. J. S. Pigott (top right), Gulf Research and Development Co., continue on the Council as past-presidents. All vice-presidents representing activities also serve on the Council. Shown below are the three new councilors.

G. E. Burks

G. E. Burks, chief engineer of Caterpillar Tractor Co., is in charge of design of all Caterpillar products. He came to Caterpillar in 1929 through the Holt Mfg. Co. of Stockton, Calif.

From Stockton, he was transferred in 1930 to San Leandro, working there first as a designer, then in 1934 heading a small engineering and research group after the Engineering Department had been consolidated in the Peoria plant.

Burks went to Peoria in 1938 to become assistant chief engineer, concentrating on engine design. In 1942 he assumed his present position.

He is a member of the ASM and takes an active part in interesting young men in engineering societies.

Norman H. Daniel

Norman H. Daniel joined General Motors of Canada in 1920 and has alternated between its engineering, production, service, and sales activities ever since.

In 1942, he went to London to develop the General Motors of Canada technical liaison group, which worked in England and Belgium with the British and Canadian forces. On his return, he became manager, diesel division, his present position.

He graduated from the University of Toronto in 1915 as a civil engineer and went overseas the same year with the Canadian Army.

Daniel was Canadian Section Chairman in 1940-1941.

Earle A. Ryder

Earle A. Ryder was on the original engineering staff when Pratt & Whitney Aircraft was formed in 1925, and he has been prominent in its design, testing, and research departments ever since.

After graduating from Cornell with a degree in mechanical engineering in 1911, he worked as a draftsman for several automobile companies in Indianapolis. Then in 1914 he joined Simplex Automobile Co. and took up aircraft engine design, his major interest from that time on. He gained more experience on aircraft engines as assistant engineer with Aeromarine.

Since joining in 1911, he has served SAE in many offices, most recently as vice-president representing aircraft powerplant engineering in 1946.

VICE-PRESIDENTS

Frank S. Spring

Vice-President, Body Activity

Frank S. Spring has had a hand in design of Hudson Motor Co.'s cars for 20 years, first as a consultant on the 1928 and 1929 models, and since 1931 as a member of the engineering staff.

Educated in Europe as an engineer, he returned to the United States and served as an aeronautical engineer with the Army Signal Corps during World War I. After the war, Spring joined the engineering staff of the Paige-Detroit Motor Car Co., went on to the Standard Steel Car Co., and later became chief engineer of the Courier Motor Car Co. In 1923 his interest in styling led him to the Walter M. Murphy Co. in Pasadena where he designed and built custom bodies, many for motion picture stars and royalty.

Louis A. Gilmer

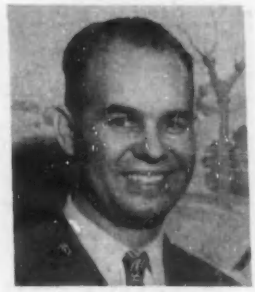
Vice-President, Tractor & Farm Machinery Activity

Louis A. Gilmer is chief engineer of the wheel tractor plant of the Oliver Corp. He joined Oliver in 1934, serving as assistant chief engineer from 1935 until 1942, when he received his present appointment.

Except for two years with Gardner-Denver Co. and Carnegie-Illinois Steel Co., all of his experience has been with industrial engines and tractors. He has been assistant chief engineer of Buda's diesel engine division, chief engineer of The International Engineering Corp., engineer for Baldwin-Southwark Co., and engine designer at John Deere Tractor Co.

Gilmer has served on the SAE Tractor and Farm Machinery Activity Committee and the SAE Tractor Technical Committee.

R. C. Loomis



Vice-President, Air Transport

R. C. Loomis became director of flying for Consolidated Vultee Aircraft Corp. last summer after working since 1940 for Trans World Airline.

At TWA he engaged in numerous projects connected with activating new aircraft; spent the war years as director of engineering for the Intercontinental Division, which engaged exclusively in contract work for the Air Transport Command; and was director of engineering and overhaul at the main overhaul base, Kansas City, when he left.

Earlier he had been a petroleum research engineer for a year with Standard Oil of California and a Naval aviator for four years after his graduation from the University of California in 1935 with a bachelor's degree in mechanical engineering.

George B. Allen
Vice-President, Passenger Car Activity

George B. Allen, now staff engineer, Chrysler Corp., has been with the organization since 1923. From development work on a Dodge four-cylinder engine project, he rose through chassis and experimental engineering positions to the post of chief engineer, passenger car division, Dodge Brothers Division, a position he held from 1929 to 1946.

He entered the automotive industry by way of the Hudson Motor Car Co. after he had acquired a B.S. in mechanical engineering from the University of Illinois. Later he worked for Chalmers, and Liberty Motor Car Co., and served as a captain, Army Ordnance Department, engineering division, during World War I.

VICE-PRESIDENTS

Max M. Roensch

Vice-President, Diesel Engine

Max M. Roensch gained background for his present work as Ethyl Corp.'s research coordinator in charge of engine research work for power, economy, and durability during his engine test and development work for the Chrysler Corp. and as chief engineer of the Cleveland Graphite Bronze Co. during 1945 and 1946.

Before joining Chrysler, he obtained a B.S. degree in mechanical engineering from Rice Institute in 1925 and an M.S. degree in 1926 from the University of Michigan, where he specialized in automotive engineering.

Besides serving Detroit Section as Vice-Chairman for the Passenger Car Activity in 1943 and 1944, he chairmanned several subcommittees of the SAE War Engineering Board and later the Diesel Engine Activity Meetings and Membership Committees.

J. L. S. Snead, Jr.

Vice-President, Transportation & Maintenance

J. L. S. Snead, Jr. worked his way up within Consolidated Freightways, Inc. to his present position as vice-president in charge of operations and maintenance. He began work for the corporation in 1930 after attending Stanford University.

Now a lieutenant colonel in the Ordnance Reserve, he served 38 months during World II as chief, maintenance division, Motor Transport Service in the Persian Gulf Command and chief, road branch, Transport Division, OMGUS in Berlin.

He is a member of the ATA Equipment Advisory Council; SAE Commercial Vehicle Nomenclature Committee; and SAE subcommittees on Classification and Evaluation of Transportation Engineering Formulas, Automotive Traffic Noise, and Automotive Exhaust Smoke.

H. L. Moir

Vice-President, Fuels & Lubricants

H. L. Moir has been with the Pure Oil Co. since 1934. He started the mechanical laboratory and moved with it to its present Northfield site as supervisor. In 1941 he became assistant chief products engineer, and the next year, technical advisor to the marketing department.

Before joining Pure Oil, he attended Northwestern University.

He is active in ASME, API, CRC, ASTM, and the National Lubricating Grease Institute.

Moir has written and presented many papers before SAE and other societies. Besides being a member of SAE Fuels and Lubricants Technical Committee, he is chairman of Subcommittee A on Transmission and Axle Lubricants and a member of Subcommittee C on Chassis Lubricants.

Vice-President, Aircraft Powerplant

Werner J. Blanchard, elected to this vice-presidency for 1949, was killed Dec. 4 when his private plane crashed near Columbus, Ohio. (See p. 78.)

A vice-president to serve in Mr. Blanchard's place will be selected by the 1949 SAE Council, in accordance with the SAE Constitution and By-Laws.

VICE-PRESIDENTS

Ernest P. Lamb

Vice-President, Truck & Bus

Ernest P. Lamb, now chief engineer of the truck division of Chrysler Corp. and a member of the Chrysler Engineering Board, has been with Chrysler since 1927.

Before, he worked for the Packard Motor Car Co., Central Axle and Gear Co., Ford Motor Co., Studebaker Corp., and the original Dodge Brothers. He attended Detroit Institute of Technology.

Detroit Section has elected him to a variety of offices, the latest being Section Chairman for 1948-1949. He is a member of a number of SAE committees, including Brake Test, Motor Coach and Motor Truck, and the Commercial Vehicle Nomenclature Committees and the Fuel Tank Subcommittee.

H. B. Knowlton

Vice-President, Engineering Materials

H. B. Knowlton has risen within the International Harvester Co. from the position he took in 1927 as plant metallurgist at Fort Wayne Works to his present position, supervisor of materials engineering.

Previously he had been in charge of metallurgical work at the Willys Morrow Co., Rock Island Arsenal, and the Case Hardening Service Co.

He studied chemistry at Indiana University and metallurgy at Harvard and Columbia.

Knowlton has served on the SAE Iron and Steel Technical Committee since 1934. During World War II, he served on the committee which adopted the National Emergency Steels and on the joint SAE-AISI committee which created the first hardenability specifications.

Karl Arnstein

Vice-President, Aircraft Activity

Dr. Karl Arnstein is vice-president in charge of engineering at Goodyear Aircraft Corp. He came to this country from Prague, in 1924 to be vice president and chief engineer of the Goodyear Zeppelin Corp., Goodyear Aircraft's predecessor.

He is a graduate of the University of Prague and holds two doctorates.

His engineering activities have ranged from airships and an airship dock to the "Comet," a light-weight, streamlined train, and Goodyear Aircraft's postwar personal amphibian, plastic components, and cross-wind landing wheels.

He is a fellow of ASME and IAS, has been a member of the NACA subcommittee on airships, and has served repeatedly on SAE aeronautical committees.

L. C. Goad
Vice-President, Production

L. C. Goad, a GMC vice-president and director, became executive in charge of the body and assembly division group last September.

This was the latest step in a GMC career that began just after his graduation from the University of Illinois in 1923 when he joined Delco-Remy's plant engineering staff. Later he started that division's storage battery program, then went to AC Spark Plug to do plant layout work, and in 1938 became general manager of AC.

As general manager of Eastern Aircraft Division during the war, he welded five GMC plants into the world's largest producer of naval aircraft.

Since, he has been group executive in charge of BOP Assembly, Dayton, and Household Appliance Divisions, and general manager of Fisher Body Division.

SCREW THREAD

American-British-Canadian Accord Marks Technical Gains for Industry

A 30-YEAR dream of industry and the military for interchangeability of American, British, and Canadian screw threads recently became reality—as the Unified Screw Thread System—in a tri-nation agreement. ASA Sectional Committee B1, which advanced the American viewpoint in these negotiations, is co-sponsored by SAE.

Although minor details remain to be ironed out, national standardizing bodies of each of the three countries are to prepare identical standards in the areas agreed upon. (See box on p. 30.) Second big feature of the new standards is that they bring to the automotive, as well as to other industries using threaded components and fasteners, more realistic classes of tolerances aimed at manufacturing economy.

The three nation accord achieves interchangeability of threaded parts by attaining unity in the four elements of screw thread geometry and dimensional limits required for mating an external with an internal thread—(1) thread angle, (2) thread form, (3) pitch (number of threads per inch), and (4) tolerances and allowances (which determine degree of fit).

Chief stumbling block to mating of American and British threaded parts—thread angle—has been cleared. Since 1845 the British used a 55-deg angle (Whitworth thread); it has been American practice to use a 60-deg angle. The new accord establishes a 60-deg angle for common, straight threads used in the three countries.

Shape Differences

Root and crest shape is the second element of thread profile where differences in practice were minimized and a happy medium reached, which insures interchangeability of British and American threaded products. British practice adhered to the rounded crest and root; the American, flat crest and root.

The British argued for the rounded form to prevent failures due to high stress concentrations. American industry held fast for the flat form for two reasons. First, tooling for the flat form is less costly than for the round. (For all practical purposes, flat tooling produces a rounded form.) Second, stress considerations are unimportant in an overwhelming majority of screw thread applications.

But the form agreed upon satisfies both groups. As shown in Fig. 1, the Unified Screw Thread System permits either a flat or rounded root for the internal thread and specifies a rounded root for the external thread, with the provision, however, that the external thread root may be flat as produced with a new or unworn tool. Fig. 1 also shows that the crest of the internal thread is flat and that the crest of the external thread may be either flat or rounded.

In practice, the British plan to continue using rounded crests and roots on the external threads and rounded roots on internal threads, contrasted with American practice of, and preference of, using flat and truncated crests and roots.

Effect of Tool Wear

Actually there is less difference between a flat and round crest or root than is at first apparent. While new tooling may cut or grind a flat on the first few pieces, the sharp corners soon wear and break off so that most of the threads produced by the tools are rounded. Rolled threads, due to limitations of the process, naturally are rounded.

Thus interchangeable assembly of American external threads and British internal threads, or vice versa, will in no way be hindered by this difference in practice.

As for the third element, pitch, the agreement represents a great step forward in reconciling differences in American and British diameter-pitch combinations.

These agreements on a common thread form and

UNITY ATTAINED

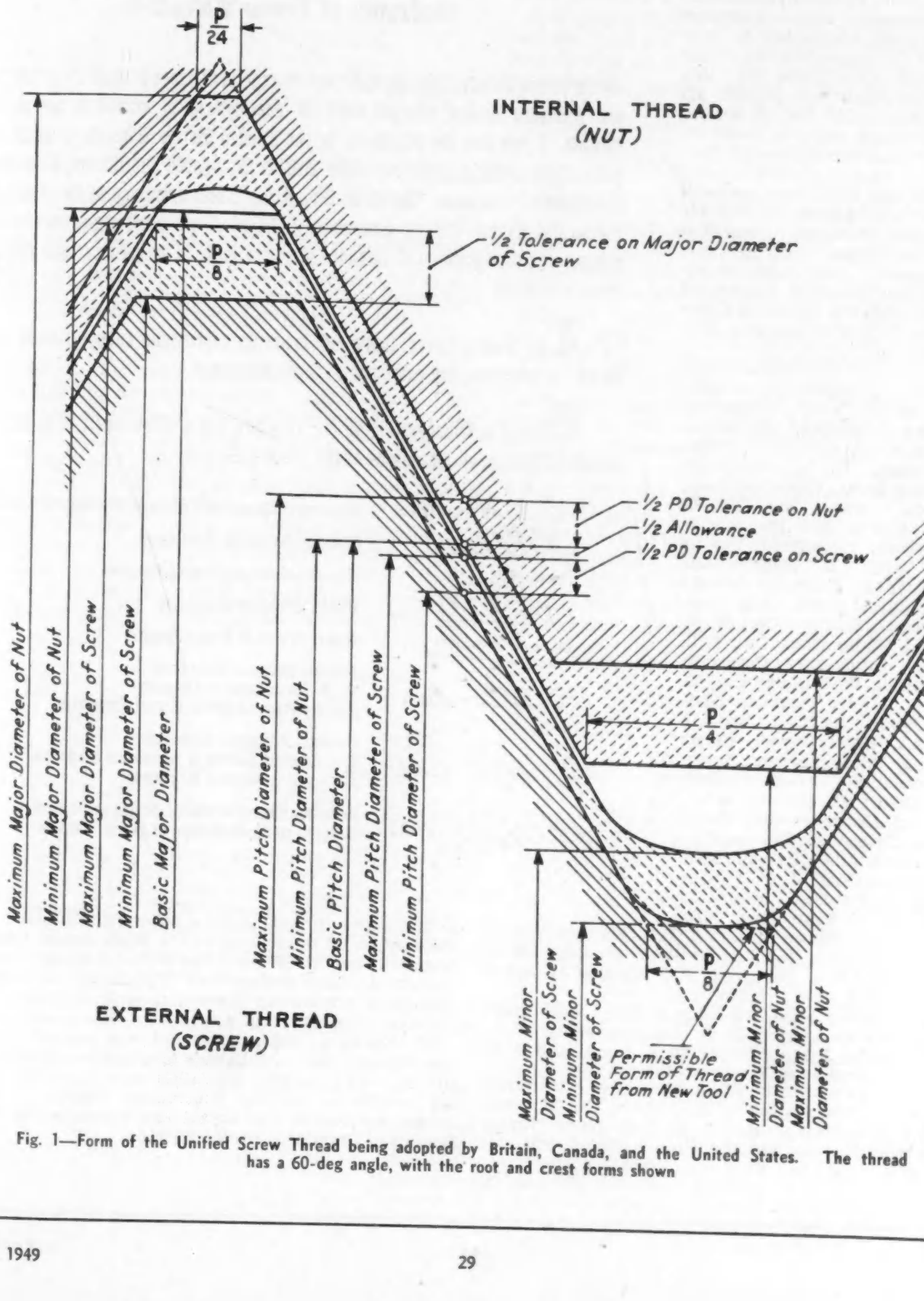


Fig. 1—Form of the Unified Screw Thread being adopted by Britain, Canada, and the United States. The thread has a 60-deg angle, with the root and crest forms shown

Significance of Agreement

Signing of this document formalized the agreement of Britain, Canada, and the United States to adopt the Unified Screw Threads.

As the text indicates, the standardizing bodies of each country—the British Standards Institution, Canadian Standards Association, and American Standards Association as well as the Interdepartmental Screw Threads Committee in this country—each will publish its own standards. But all will be substantially uniform, based on the Unified Screw Threads System.

SAE and ASME are sponsors of the American Standards Association Sectional Committee B1 that helped develop these standards. The SAE Screw Threads Committee cooperated closely with the Sectional Committee in the unification program.

Members of the SAE Committee and participants in its work are: J. M. Crawford, General Motors Corp., Sponsor; W. L. Barth, General Motors Corp., Chairman; H. A. Marchant, Chrysler Corp., Vice-Chairman; W. G. Baule, Borg-Warner Corp., Detroit Gear Division; E. J. Bryant, Greenfield Tap & Die Corp.; E. Buckingham, M.I.T.; G. Carvelli, Wright Aeronautical Corp.; G. S. Case, Lamson & Sessions Co.; W. R. Conrad, White Motor Co.; T. L. Cowles, Studebaker Corp.; P. M. Delzell, Ford Motor Co.; H. Fisher, Bendix Products Division, Bendix Aviation Corp.; D. Garrett, Kaiser-Frazer Corp.; Col. H. B. Hambleton, Interdepartmental Screw Threads Committee; P. Houser, International Harvester Co.; T. M. Logan, Caterpillar Tractor Co.; H. L. Muth, Allis-Chalmers Mfg. Co.; F. H. Ohst; J. G. Perrin; F. E. Richardson, Munitions Board; K. G. Roth, Mack Mfg. Co.; F. Tisch, Phoell Mfg. Co.; C. D. Walters, Willys-Overland Motors, Inc.; F. E. Story, Packard Motor Car Co.; and C. G. Davey and R. F. Holmes, AC Spark Plug Division, GMC, liaison.

Declaration of Accord

with respect to the

Unification of Screw Threads

It is hereby declared that the undersigned, representatives of their Government and Industry Bodies, charged with the development of standards for screw threads, Agree that the standards for the Unified Screw Threads given in the publications of the Committees of the British Standards Institution, Canadian Standards Association, American Standards Association and of the Interdepartmental Screw Thread Committee fulfill all of the basic requirements for general interchangeability of threaded products made in accordance with any of these standards.

The Bodies noted above will maintain continuous cooperation in the further development and extension of these standards.

Signed in Washington, D. C., this 18th day of November, 1948, at the National Bureau of Standards of the United States.

C. D. Howe	Ministry of Trade and Commerce, Dominion of Canada
J. G. Morrow	Canadian Standards Association
T. R. B. Sanders	Ministry of Supply, United Kingdom
[illegible]	British Standards Institution
[illegible]	Representative of British Industry
E U Condon	National Bureau of Standards U. S. Department of Commerce Interdepartmental Screw Thread Committee
[illegible]	American Standards Association The American Society of Mechanical Engineers Society of Automotive Engineers
William L. Batt	Sponsors Council of United States and United Kingdom on the Unification of Screw Threads

At the policy level, the United States was represented by a Sponsors Council, chairmanned by W. L. Batt, on which J. M. Crawford, W. S. James, and H. T. Woolson served as SAE representatives.

This accord marks the culmination of efforts toward unifications first started in 1919. World War II again pointed up acuteness of differences in screw thread practice in Britain and the United States. For example, screw threads posed a substantial problem at Packard in its production of the Rolls Royce Merlin engine. The British used five different screw thread systems in this engine—the Whitworth, a British Standards Institution thread, a metric thread, an instrument thread, and a truncated Whitworth.

At Ottawa in 1945, agreement was reached on a basic thread form. With this groundwork American, British, and Canadian specialists ironed out remaining details at several subsequent sessions. The formal agreement was signed last November at the Bureau of Standards in Washington.

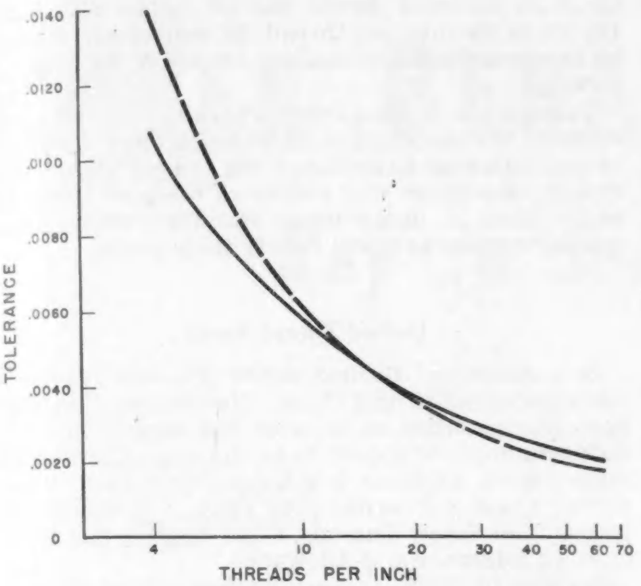


Fig. 2—As shown here, the new Classes of tolerances are more rational than the old ones. Class 2B tolerances (solid line) gives smaller tolerances in the coarser pitches and greater tolerances in the finer pitches than does Class 2 (dotted line). The new Classes better reflect performance of the thread-forming tool in production. Both curves shown are for the National Coarse Series

pitches form the basic building blocks for interchangeability of American and British threads. Accord reached on tolerance and allowance, the fourth element of screw thread technology, further enhances interchangeability. But aside from their international aspect, the Unified tolerances represent an improvement over, and refinement of, American practice. These improvements and refinements are particularly important to mass production industries, such as the automotive.

All the Classes of Unified threads are based on principles of what is known as the Class A formulation. Class A, incidentally, is the outgrowth of automotive interest of some years standing in a thread that would eliminate galling and seizure during high-cycle wrenching as well as alleviate difficulties with plated components.

Some years ago, as a result of automotive interest based on practical considerations of manufacturing and engineering requirements, joint industry conferences were held to develop an external thread class with an allowance. (This Class would provide a clearance between the mated threads even when engaging the maximum size screw and minimum size nut permitted by the tolerances.)

Although this development progressed entirely independent of the unification program, it ultimately served as the key to interchangeability and harmonization of British and American thread practice.

Tolerance Formula Sounder

The Class A formulation also provided the unification effort with a more realistic basis for tolerances. Previously it had been the practice to predicate tolerance on pitch alone. In the Unified Screw Thread System, tolerances are based on pitch, diameter, and length of engagement. As an outgrowth of years of experience, the new tolerance formulas have been practically weighted for each of these three factors.

For example, on Unified threads, Class 2A, 7/16-14 and 7/8-14, the pitch-diameter tolerances are 0.0047 and 0.0054, respectively. Obviously these are more reasonable than the tolerance of 0.0049 specified for both diameters in the American National Coarse Series, Class 2.

This demonstrates the greater rationality of the Unified Thread Classes from an engineering standpoint. It is quite apparent that greater tolerances are reasonable for a larger diameter than for a smaller one. By arbitrarily setting a fixed tolerance,

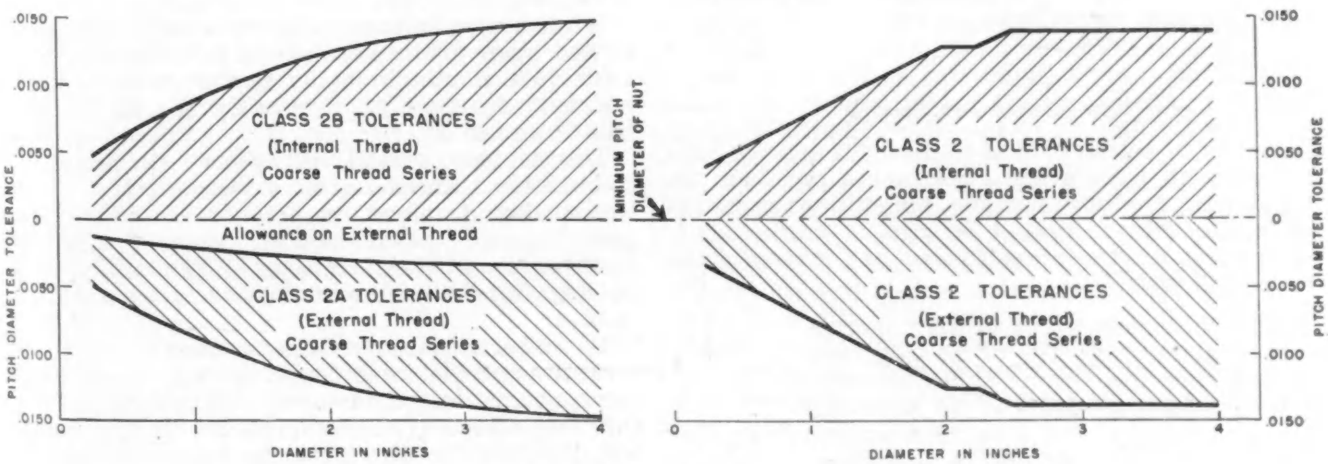


Fig. 3—This points up a major difference between the old and new Classes for commercial fasteners and nuts and bolts. With a maximum nut and minimum bolt, Classes 2A and 2B, at left, provide a clearance between the mating parts. Class 2, as shown at right, does not. Also note that Class 2 tolerances are the same for both the 2½-in. diameter and 4-in. diameter threads. Classes 2A and 2B are more rational in that tolerances increase with diameter

regardless of diameter (as with the former tolerance Classes), tool life is penalized. Customers refused to take this economic penalty; they deviated from the American Standard and specified special threads.

Another difficulty with the old tolerance Classes arose from the fact that the thread-forming tool "didn't know the old tolerance formula," as one screw threads specialist pointed out. In other words, shortcoming of the old system stemmed from incompatibility of the formula with production limitations.

Specified tolerances for the fine pitches were too low, shortening tool life. Yet the same formula yielded too high a tolerance for coarser pitches. Study, based on experience with what the thread-forming tool actually will do in the shop, permitted development of more rational Classes of tolerances which correct defects of the old ones. Fig. 2 demonstrates this.

Here are the new Classes:

1. Classes 1A and 1B—These Classes are intended for Ordnance and special uses. They cover threaded parts where quick and easy assembly is necessary, where liberal allowance is required to permit ready assembly, even with slightly bruised or dirty threads.

2. Classes 2A and 2B—These Classes are "naturals" for bolts, nuts, screws, and similar commercially threaded fasteners, for which some one million tons of steel are consumed annually in this country. The moderate allowance on Class 2A minimizes galling and seizure in high-cycle assembly and use. It also gives a clearance for plating. Significance of this allowance, as opposed to lack of an allowance in Class 2, is demonstrated in Fig. 3. Tolerances on Class 2B are realistic for mass production of commercial nuts.

3. Classes 3A and 3B—These Classes are useful for such applications where closer tolerances than Classes 2A and 2B are required. Class 3A provides no allowance; but since tolerances on "go" gages are within limits of size of the product, the gages will assure a slight clearance between the parts made to the maximum metal limits.

How Classes Are Related

Beauty of this system is that all Classes are consistent with each other. Tolerances for Class 2A are derived from the formula, reflecting increments of pitch, diameter, and length of engagement. Tolerances for the other Classes are derived from 2A, as follows:

- 2B tolerance—130% of 2A tolerance
- 2A allowance—30% of 2A tolerance
- 1A allowance—same as 2A allowance
- 1A tolerance—150% of 2A tolerance
- 1B tolerance—195% of 2A tolerance
- 3A tolerance—75% of 2A tolerance
- 3B tolerance—112.5% of 2A tolerance

Fit of threaded parts should be adapted to requirements of specific applications by selecting the proper combination of thread Classes. For example, Class 2A external thread can be mated with Class 1B, 2B, or 3B internal thread, or, conversely, a Class 3B internal thread with Class 1A, 2A, or 3A external thread.

Because the Unified Screw Threads establish more realistic tolerances, it is anticipated that there will be less tendency to deviate from the standard. Obviously economies will accrue to users of threaded parts since in many cases standard rather than special threads now will satisfy their needs.

Unified Thread Range

In a sense the Unified Screw Threads involve a new concept of thread Class. Heretofore, Class had been misconstrued as fit, with the implication that both components should have the same Class tolerances—such as Class 2 internal with Class 2 external, Class 3 internal with Class 3 external. In the Unified Screw Threads, Class denotes the tolerance, or tolerance and allowance.

Because of their long-established and widespread use, Classes 2 and 3 are retained in the American Standard. Despite their shortcomings in some respects and their known inconsistencies, Classes 2 and 3 are emminently suitable for some applications. Complete transition to the new Classes may, therefore, take some years.

The American Standard will be revised to include the Unified Screw Threads. Classes 1A, 1B, 2A, 2B, 3A, and 3B in the Coarse and Fine Series are in agreement with what the British will publish. These pitch and class combinations will carry the designation UNC and UNF, interpreted in this country as Unified National Coarse and Unified National Fine, respectively; in Britain, as Unified Coarse and Unified Fine.

The UNC and UNF designations hold only for threads $\frac{1}{4}$ to 4 in. in diameter in the Coarse Series and for threads $\frac{1}{4}$ to $1\frac{1}{2}$ in. in diameter in the Fine Series. For numbered sizes and larger diameter threads, the designations are continued as NC and NF; while they will be continued only in the American Standard, unification effort on them is still under way.

While major features of the Standards have been agreed upon to the satisfaction of the three countries, several minor details remain unsettled; but harmony on these points is expected by the time this is published.

This is the essential difference: On fine-pitch combinations Americans allow less tolerance on internal thread minor diameter of large-diameter parts than on smaller diameter parts. The British, however, use a tolerance based on pitch only, without regard to diameter or diameter-pitch combination.

An editorial subcommittee, consisting of representatives of the three countries, was appointed to resolve remaining differences. Upon completion of this job, ASA Sectional Committee B1 will recommend to ASA that the American Standard be modified to incorporate the Unified Screw Threads. The SAE Screw Threads Committee will recommend to the SAE Technical Board that the modified American Standard containing the Unified Screw Threads be published in the SAE Handbook.

DRIVER BEHAVIOR—

Key to Safe Highway Design

The Second SAE
DAVID BEECROFT
Memorial Lecture
November 16, 1948

by Thomas H. MacDonald
Commissioner
U. S. Public Roads Administration

THROUGH the many years of his activities in the rapidly expanding field of automotive engineering and motor vehicle utilization, David Beecroft was a positive force for technical progress. He constantly brought to his associates the impression of a restless inner drive to secure action, and an eagerness—merging into impatience—to defeat delays in moving toward higher standards of excellence for the many diverse components that must be integrated and perfected to provide the desired end product . . . efficient highway transport. He insisted that the attack on each problem accord with sound techniques, and believed that advance comes through research. In 1921, when president of the Society of Automotive Engineers, he said: "The roots of the present are always found in the past, and we must study the past if we are to proceed correctly in interpreting sanely the days that are to come."

We might, perhaps, modestly record the progress that has been made in highway transport development since Beecroft gave expression to this principle. After four decades of accelerated growth in the extent and varieties of services provided by the motor vehicle, it is self-evident that in this period no other single factor has so profoundly affected the pattern of social and economic life in these United States. A particularly impressive chapter of the record would disclose the realized strength that highway transport provided the United States for both defense and offense during World War II.

It is more consistent, however, with Beecroft's philosophy, to use the experience of the past to insure the complete rejection of the fatalistic suspicion that the current inefficiencies and hazards of highway transport are necessarily inherent.

If we are to gain mastery over highway transport as an efficient tool for national progress, and stop the toll that we are paying for its use in the tragic loss of life, the permanent injuries, and the financial costs of accidents that no nation, however wealthy, can afford, we must critically re-examine our policies and practices—particularly the thinking back of these, to find the causes that are responsible for our failures. We know we have taken many wrong turnings. Changing conditions require new horizons in our applied techniques as knowledge is unfolded and experience is more precisely interpreted. It is profitless to speculate upon what we might have done had we foreseen in the early years a reasonable fraction of the dimensions to which highway transport was so rapidly to grow, or had we anticipated more realistically its characteristics in actual operation.

It is a high honor to follow, in this series of papers, Paul G. Hoffman, who in 1947 presented the David Beecroft lecture. There is, in the general confidence of his fitness to carry the world-wide responsibility as head of the Economic Cooperation Administration, a recognition of his major contribution and efforts to bring highway safety into effective unity with our every-day living.

In the ECA program the United States has accepted high international responsibility in the struggle to achieve democracy, which essentially means cooperation and coordination. The principle must be accepted and applied to every major feature of our national life if we are to be an example of our ideology worthy of the emulation of other nations. Highway transport consists of so many elements that we can only secure an excellent standard of service as we approach complete cooperation and coordination. On this premise, it appears to be responsive to the purpose behind the series of papers set in motion by Beecroft, to explore the present state of the art in the single field of highway design in relation to highway safety.

In this particular and limited field there is urgent

Additional copies of this lecture, bound as a 36-page booklet, are available from SAE Special Publications Department at 50¢ to SAE members and non-profit organizations; $1.00 to non-members. Quantity prices on request.

need for a major shift in the approach to the determination of the geometric design. Since major changes in our thinking and in our policies applied in this field are indicated by the findings of intensive research now available, it may, by inference, be expected that need for major changes exists in other elements of highway transport. It is hoped that future papers in this series may present the record of the present, and also new concepts in the allied fields of motor vehicle design, motor vehicle administration, particularly driver licensing and driver training, traffic laws, enforcement and safety education designed to fortify driver behavior with disciplined attitudes of mind. These are all interrelated and interdependent, and our mastery of the whole problem of street and highway transport with safety depends upon mastery in each of these fields.

This paper purports only to record the devoted work of many individuals and many organizations to advance the cause of highway safety. The Action Program of the president's Highway Safety Conference, the extensive work of the Automotive Safety Foundation, that of the National Safety Council, and of many others, are reflected in the conclusions reached. The factual data are the product of the Department of Research of the Public Roads Administration under Deputy Commissioner H. S. Fairbank and, in particular, result from detailed research of O. K. Normann, Carl Saal, C. W. Prisk, W. P. Walker, A. Taragin, and others who have engaged in the field of traffic research intensively and devotedly over many years.

The application of such data to design practices of Public Roads is the product of the Division of Design under Deputy Commissioner H. E. Hilts and his associates. There is particular response to the advance in design requirements by the Urban Division under Joseph Barnett.

The effort has been made to eliminate personal opinion, and to substitute conclusions supported by detailed observations of controlled research carried on over a sufficient period and with adequate repetition to justify confidence in the results. It is, however, not the intention to reflect an implication of finality. Continuing research will refine and illumine problems which are as yet obscure, but it is certain that driver behavior (en masse) is the key to safe highway design.

Conclusions

We have reached the point in our knowledge of the manner in which highways are used by the mass of traffic, to coordinate driver behavior under prevailing traffic conditions, and the geometric details of highway design. The degree to which the criteria so determined are accepted and intelligently applied in practice will determine the degree of safe efficiency of our future highways.

Our principally used street and highway systems are largely the product of the past one-third century. Most of the improved mileage has been built under public pressures and also legislative edict, to stretch the dollars over maximum lengths. In general, the design tolerances have been too meager for today's quantity and characteristics of traffic. Overloaded highways (by traffic capacity) are one of the chief underlying causes of highway accidents.

Highway design (geometric) to induce proper driver behavior in traffic streams will require rebuilding or rehabilitation of the major mileage of both the primary and principal secondary routes to more liberal standards. The cost will exceed annual expenditures heretofore reached, and will require a long period—a minimum of 15 years and probably longer. Carefully planned annual programs of rehabilitation are an emergency need.

The appealing angle of highways designed for safe operation, is that safe designs cost no more than unsafe designs if total costs are considered. The initial cost of constructing a highway is only one element, and far less costly than other elements, of the total annual cost of highway transport. The costs of owning, maintaining and operating more than 40,000,000 motor vehicles are many times the expenditure for highway construction and maintenance. When these total costs to road users are considered, plus the value of lost time for the millions of passenger cars used for business and for all vehicles operated by paid drivers, and the value of saving in time on the investment of farmers, merchants and industrialists in their vehicles and in the mechandise carried, there are few highways indeed for which the small additional investment to design for safer operation cannot be justified on the economic basis of returns to road users. When there are added to these costs the cost of highway accidents that can be prevented by highways designed for safety, the economy of such highways is unassailable. Incidentally, highway engineers have too long wrecked professional conviction against the stone wall of comparative "per-mile" costs. We need a new concept that recognizes the actual passenger-mile and ton-mile services returned as the realistic measure of highway construction costs.

Highways designed for safety on the national scale will be realized all too slowly. There are many accidents which highways designed within cost possibilities cannot prevent. The only hope of maintaining the downward trend of accidents, particularly fatal accidents, is the vigorous application, enforcement and popular support of the Action Program of the President's Highway Safety Conference.

Background of Highway Design

For too long, and in too great degree, highway design has been distorted by the tyranny of wrong concepts. Most important of these in its adverse impacts is the error of thinking of the motor vehicle as static in relation to the highway. In use the vehicle is dynamic and takes on very different qualities.

When the motor vehicle first appeared, it was held to be a legal interloper on highways whose function was to serve horsedrawn traffic. As the number increased, only minor concessions were made to its higher speed in the way of super-elevated curves—probably borrowed from prior railroad practice. The effects of railway engineering tenets upon highway design are evidenced by the meager tolerances which have been built into our roads, and which reflect operations on fixed tracks not subject to deviation from course. The motor vehicle in motion is not only highly flexible; at very low densities of traffic the operation begins to take on the character of the stream flow, and the individual vehicle loses its identity and its freedom. As an integral part of a

traffic stream, each vehicle affects and is affected by, all of the other vehicles in its own flow line, and in contiguous streams. The old adage—the proper study of mankind is man—is not only scientifically correct, but is the only approach to the problem of highway design with maximum safety. Human behavior at the wheel, with foot on the accelerator rather than the brake, is the all-important criterion for highway design. The implication here is not an invitation to speed, or to design with the objective of high speeds. Driver behavior en masse reflects normally average rural speeds of 42—48 mph when reasonable freedom is permitted. As cars are designed, the foot on the accelerator is the normal driving position, and through the accelerator the driver expresses not only his desire to reach an objective, but in addition a wide range of reactions that may be conscious emotions or unconscious reflexes. The driver en masse is not designed for high speeds with safety. Once the mean and range of human behavior are determined by precise measurements extended to thousands of observations until the general pattern emerges, the design limits thus fixed will have sufficient tolerance to provide for the usual departures from the norm. Highway capacity adjusted to traffic volume is a major factor in safe highway design. True economy is served only if this test is met, and thus safety becomes directly a measure of efficient as well as economical design.

The ratio of commercial vehicles to passenger cars has important effects upon the road capacity to carry traffic. In 1904 the ratio of trucks and buses to passenger cars was 1 to 78; by 1910 this ratio had become 1 to 45; in 1920, 1 to 7.3; 1930, 1 to 6.5; 1940, 1 to 5.9; and it is expected that this year the ratio will be about 1 to 4.5 (See Table 1.) The percentage of commercial vehicles in the total daily traffic flow is continuing to increase, and for this reason more adequate recognition of the requirements of such traffic must be incorporated in the design to insure safe, efficient operation of all traffic.

The influence of increasing the percentage of commercial vehicles upon the total capacity on multi-lane highways, under the favorable conditions of uninterrupted flow, is illustrated by the following:

Effect of commercial vehicles and grades on practical capacities of multi-lane facilities

Commercial vehicles	Level terrain	Rolling terrain
Per cent	Per cent of passenger car capacity on level terrain	
None	100	100
10	91	77
20	83	63

On two-lane highways the limitations of capacity are more severe.

In the years just prior to 1946 the national fatality rate was about 12.0 deaths per 100,000,000 vehicle-miles of travel. In January, 1946, the rate was 12.4. The president's Highway Safety Conference was

Table 1—Registrations

Years	Automobiles	Trucks and Buses	Ratio Trucks and Buses to Automobiles	Total
1904	54,590	700	1/78.0	55,290
1910	458,377	10,123	1/45.3	468,500
1920	8,131,522	1,107,639	1/ 7.3	9,239,161
1930	22,972,745	3,559,254	1/ 6.5	26,531,999
1940	27,372,397	4,663,027	1/ 5.9	32,035,424
1947	30,718,852	6,641,611	1/ 4.6	37,360,463
1948[1]	33,225,000	7,332,000	1/ 4.5	40,557,000

[1] Estimated.

called in May, 1946, and notwithstanding the bad record of the first three months of that year, the upward trend was halted and turned abruptly downward so effectively that the year ended with a rate of 9.8. The wholehearted support, and the devoted interest and efforts of organizations, officials and the public in putting into effect the action program developed through the Conference, are mainly responsible for the reduction in the fatality record to the estimated rate for 1948 of 7.8 per 100,000,000 vehicle-miles. As this rate is lowered we must expect to reach a critical point at which a continuing decrease will prove impossible through education, enforcement and the other means which have been responsible for the splendid record made since May of 1946. In addition there must be the reduction, through the general use of higher standards of highway design, of the current fantastically high accident potentials. The astronomical number of accidents that do not happen is terrifying. As traffic volume increases the accident possibilities, that is, the pressures for accidents, build up in geometric ratio. The accident potentials can only be reduced with certainty by reducing the possible conflicts of traffic units.

We know that major reductions in the fatality rate can be made by providing properly designed, modern highway facilities, as is evidenced by the record of highways on which the accident potentials are greatly reduced. The following highways carry large volumes of traffic and have fatality rates as low as one-fifth or one-third the national average because of the controlled access design in which conflicts of all kinds—cross traffic, pe lestrians, and traffic entering along the roadsides—have been materially reduced or eliminated.

Facility	Rate (Deaths per 100 million vehicle-miles)
Merritt and Wilbur Cross Parkways (1946)	2.5
Chicago Outer Drive (1946)	2.9
Riverside Drive (California) (1941-44)	3.0
Arroyo Seco Parkway (1941-44)	3.9
Metropolitan New York Parkway System (1938-48)	2.5
Pentagon Network, Washington, D. C. (1942-48)	1.5

The Pentagon Network is composed of 17 miles of one-way through roads, 7.7 miles of one-way connecting ramps and 2.3 miles of two-way local service roads—a total of 27 miles—on which the vehicle mileage for the period of slightly more than six years since its construction is estimated at 337,500,000. Five persons, three of whom were pedestrians, have been killed during this period. Further reference will be made to the observations of driver behavior on the roads of this system.

Under the inspired, at times militant, leadership of Robert Moses, the Metropolitan New York Parkway System has set an example of highways designed on a scale commensurate with traffic requirements of reasonable speed with safety. The system, steadily expanding, now consists of 164 miles of multi-lane roadway, much of which is divided. The obstacles which have been met are somewhat indicated by the required 208 bridges. There are two details of design that cannot be over-commended that have been or are being put into practice as safety measures. One is the installation of center curbs on the earlier undivided parkways. These have successfully eliminated the deadly head-on collisions. The other is the installation of paving blocks to support heavy vehicles on the shoulders when disabled.

The Action Program of the President's Highway Safety Conference lays great and proper stress upon the acceptance of individual responsibility for safety on the highways. Educators are increasingly stressing the importance of "true personal participation" in contrast to activity unrelated to the subject of study. Contrariness and individualism in respect to a desirable course of conduct disappear once the individual accepts his responsibility for safety of himself and others on the highway.

The responsibility of the individual toward the public to preserve highway safety should be activated by school instruction, town meetings, community forums, local coordinating and action committees, support by the press, discussion groups—all of which are calculated to impress the individual with his responsibility to the public and in this way mold or re-mold the habits and attitudes relating to safety on the highways.

When these approaches to the problem of accidents have been used, there still remains the very pertinent query, "What is the proper attitude of the public toward the driver?" Basically, the individual driver has his limitations of habits, of capabilities, and the handicaps of his own perception and reaction times. Each driver in a stream of traffic, in a high degress loses his freedom of action, and is circumscribed by the action of others. His performance is limited by, and becomes part of, the traffic flow, which is a composite of the reactions of a multitude of drivers. Thus, the responsibility of the public to the individual driver is, first, to determine the characteristics of traffic flow lines, and second, in harmony with this knowledge, to provide the facilities for safe use. The dynamics of these speeding streams of traffic most directly influence the design features which we term geometric. These are alignment, profile, plan of intersection, clearances, horizontal dimensions of the highway cross-section, and the many details which we group under the general term of highway design.

Hazards of Design Characteristics

The outstanding hazard of our streets and highways is under-capacity for the traffic load. Nearly half of the rural highways carrying 1000 vehicles per day and over are less than 20 ft in width. On each mile of such highway, over 60 times per hr, or once each minute, a vehicle is encroaching upon the left lane when meeting an oncoming vehicle. Expanding these figures to the many miles of rural highways in this country, the accident potential reaches unrealized dimensions. The length of time that a vehicle in passing another vehicle occupies the lane used by the oncoming traffic, depends upon the width of pavement. On an 18-ft pavement vehicles occupying the left lane require 43% longer in passing than on pavements 24 ft wide. The pavement of the lesser width is not only more hazardous, but provides only 70% of the capacity of the 24-ft pavement.

Adequate shoulders are necessary to the efficiency of motor vehicle operation. They are effective in increasing the traffic capacity of the highway, since bituminous treated shoulders 4 ft or more in width, adjacent to 18- and 20-ft pavements, as compared with grass or gravel shoulders, increase the effective surface width approximately 2 ft. Increasing the effective pavement width results in fewer vehicles encroaching upon the left lane of traffic, and thus increases the traffic-carrying capacity of the highway. Shoulders also play a very important role in accident prevention in both rural and suburban areas where pedestrians are involved. In 1947, 25% of all rural pedestrian fatalities occurred while pedestrians were walking on the roadway. Were adequate shoulders available of the character necessary to provide usable footpaths, many lives would be saved. To gain the advantage of adequate shoulders, there should be no vertical obstructions such as retaining walls, bridge trusses, utility poles, guard rails, parked vehicles or other objects near the traveled way. Obstacles at the edge of a 10-ft lane cause vehicles to travel 2.6 ft farther from the edge of the pavement than when the obstacles are not present. Even for lanes 12 ft wide the same positioning of obstacles causes vehicles to travel 1.8 ft farther from the pavement edge. Obstacles 4 ft or more from the pavement edge have only minor effect. The roadside obstacles, therefore, have the effect of reducing the pavement width. Adequate width of shoulder and a suitable surface for parked vehicles are necessary for every highway regardless of its width. On the Merritt Parkway in Connecticut, two-thirds of the fatalities resulting from collisions between vehicles have involved a parked vehicle on the roadway. The German Autobahnen were built with divided paved roadways, each 29.25 ft in width, thus providing capacity greatly in excess of normal requirements. The shoulder width was one meter. In 1938, after a very few years of use of a limited mileage, the Inspector General, Dr. Fritz Todt, the official in charge, stated that the decision had been made to add wider shoulders because of numerous accidents caused by vehicles standing on the pavements. This experience is compelling in establishing proof of the danger inherent in the vehicle parked on the roadway. Every other element which we rate as contributory was absent, and the

standing vehicle per se was the cause of the accidents.

Where sight distances on two-lane roads are so short that passing would be hazardous, it is customary to stripe no-passing zones. Observations were made on a 3400-ft length of highway, of which about one-fourth was marked "no passing" by reason of sight distances below 400 ft. Of the total number of passings made within this 3400-ft length, more than 10% were started or completed in the restricted zone. On roads where no-passing restrictions comprise as much as 40% of their length, the volume of traffic that can be satisfactorily and safely accommodated is only about 80% of that which can be carried on a similar highway free from sight distance restrictions.

The road margin is the critical line of hazard on many of our existing highways. Recognition of this situation appears in a project just initiated in Michigan, in which a study of the locale of accidents with respect to taverns, gas stations, restaurants and other roadside establishments is to supplement the more conventional facts analyzed in studies of traffic accidents. The unrestricted use of the road margin for entrance and exit at such locations causes driver confusion, disorderly parking and other operating hazards. The growth in the number and popularity of outdoor drive-in theaters is but a single example of the commercial exploitation of the roadside. The safety of motoring audiences as they enter or leave these establishments in large numbers, has become a necessary concern of highway authorities because of the effect on operating conditions on the adjoining highways. The most difficult obstacles the highway engineer faces in his effort to build safety into the highways are the lack of legal authority and effective legal machinery provided to acquire sufficient right of way and to control the entrance to the public highway from abutting property.

A characteristic serious fault of drivers is that of following too closely a car traveling in the same lane. The speed and the interval between the cars do not permit adequate perception and reaction time for the rear car to stop if the car ahead is brought to an unexpected stop. This type of accident has the potentials of a whole series of accidents, of tying up traffic, of causing much property damage, and sometimes serious or fatal accidents. The grave implications of this very common practice are indicated by Table 6. The perception and reaction times vary with individuals, but a safe assumption would hardly be less than 1.5 sec. Tests of drivers have shown that the minimum reasonable reaction time alone is ¾ sec.

The average time spacing between vehicles following at the same speed, for all speeds and for both two- and four-lane roads, is 1.58 sec; 16.2% of the traffic will have a time spacing of 0.75 sec or about one-half the average.

Road Design for Safe Operation

• *Alignment*—The alignment must be adjusted to the volume and type of traffic, the driving characteristics of the operators, and the dynamic effects of the mass movement. The alignment selected, whether the highway be two, four or more lanes wide, determines how effectively and safely the completed facility will meet the demands of traffic. Sight distances between 1500 and 2000 ft long are essential on any rural two-lane highway. The percentage of the length where sight distances of this magnitude should be available will depend on the volume and type of traffic which the highway must accomodate. On our main highways carrying high-speed through traffic, a sight distance of at least 1500 ft should be available on a minimum of 60% of the route length, if the highway is to accommodate peak traffic volumes as high as 500 vehicles per hr with safety. If it is unavoidable to introduce curvature which restricts the sight distance, it is essential to select an alignment free from sudden changes that come as a surprise to the operator. Curves at the ends of long tangents are definitely more hazardous than the same curves located where the general alignment is made up of a series of curves.

• *Practical Working Capacities*—Accidents are inevitable on overloaded highways. Safe highways must have sufficient capacity to permit drivers to operate at reasonable speeds. On main rural highways drivers generally accept as reasonable, average running speeds of 45-50 mph during the peak volumes. On urban expressways, a speed of 30-35 mph during peak traffic volumes is reasonable.

The working capacities for modern rural roads in terms of passenger cars per lane are 450 per hr for a two-lane road, and 1000 per hr for the lanes in the direction of heavier travel on multi-lane roads. At these traffic volumes, under ideal roadway conditions, the drivers who so desire can safely travel at the above speed on rural roads, although the average speed of all vehicles at any given point will be about 42 mph compared to an average speed of about 48 mph during low traffic densities.

In urban areas the maximum practical working capacity for a modern multi-lane expressway is 1500 passenger cars per hr for each lane in the direction of heavier travel. At this volume, drivers who so desire can safely average 35-40 mph, and the average speed of all vehicles will be between 30-35 mph. At this working point, unusually high volumes

Table 2—Speed Zones versus Uniform Legal Limit for State. Relation between Curvature and Safe Speeds.

Degree of Curvature	Radius of Curvature	Suggested Zone Speed*
	Ft	mph
3	1910	60
4	1433	53
5	1146	48
6	955	43
7	819	40
8	717	37
9	637	35
10	574	33
11	522	32
12	478	31
13	442	30
14	410	29

* Before zoning speeds are posted the curves should be tested by competent observers to determine the safe speed for the particular conditions.

that occur frequently for short periods can be handled without complete congestion.

• *Lane Widths*—The lane widths used for the design of our highways must be based on vehicles in motion—not on the actual size of the vehicles standing still. Most of our main highways have sufficient traffic of commercial vehicles to require 12-ft lanes for safe operating conditions. Eleven-foot lanes must only be considered for highways carrying less than 1000 vehicles per day. The reduction in capacity by narrowing lanes is not only unsafe; it is definitely uneconomical; that is, the cost of the additional width is less than the proportional increase in capacity.

Effect of lane width on capacity

Lane width	2-lane rural roads At possible capacities	2-lane rural roads At practical capacities	Multi-lane expressways at practical urban capacities
Feet	Percentage of 12-foot lane capacity		
12	100	100	100
11	88	86	97
10	81	77	91
9	76	70	81

• *Two-Lane Highway Limitations*—The accident experience on two-lane highways shows that the death rate per million vehicle-miles increases with an increase in the traffic volume. Operating conditions on the average two-lane highway are not satisfactory when traffic volumes exceed 4000 vehicles per day in flat terrain, or 3300 vehicles per day in rolling terrain. It is only for extremely low daily traffic volumes that a two-lane highway can safely accommodate a vehicle traveling over 60 mph, regardless of excellent alignment. Design speeds that exceed 60 mph, to provide safe operating conditions require four-lane divided highways if the volume exceeds 3000 vehicles per day. On free flowing highways where the higher speeds are safer, this very fact automatically lowers the top range by permitting a constant rate which satisfies most drivers. The average actual rate for two-lane highways of modern superior design is about 48 mph.

There is confusion of the terms "overload" and "congestion." Congestion approaching stagnation may lower the serious accidents, but at the same time it defeats the utility of highway transport. Any concept that congested highways are safer completely overlooks the fact that each route has its own characteristic pattern of daily use. It may have an hour or a fraction of an hour once or twice daily of congestion at peak traffic periods. These periods of congestion causing stagnation or incipient stagnation may be productive of numerous but not fatal accidents. The remainder of each 24 hr constitutes 90-95% of the time, during which there are much longer periods when the route is overloaded and a breeder of accidents.

• *Multi-Lane Highways*—Multi-lane highways of the divided type will accommodate three to six times as many vehicles per lane as a two-lane highway, and provide greater safety. For average conditions, the width should be increased from four to six lanes when the volume exceeds 18,000 vehicles per day in rural areas, or 32,000 vehicles per day in urban areas. In certain areas of the county where seasonal, daily and hourly fluctuations in traffic flow vary from the average condition, the practical capacity of a four-lane divided highway might be as much as 30% higher or lower than the above volumes.

• *Shoulders are Essential*—Shoulders that will accommodate disabled vehicles and that may be used by moving vehicles in cases of emergency during any weather conditions, are essential for safety on main highways. Adequate shoulders are also essential to realize the full capacity of the surface width. Without adequate shoulders, one disabled vehicle can reduce the capacity of both two-lane and multi-lane highways during peak periods by as much as 60%. There is at least one disabled vehicle for every 20,000 vehicle-miles of travel on our main highways.* Furthermore, adequate shoulders increase the effective surface width for traffic when no disabled vehicle is present. Without a place of refuge outside the traffic lanes, one disabled vehicle can reduce the capacity of a highway by more than one lane, especially if the lanes are less than 12 ft wide. The disabled vehicle blocks one lane and reduces the capacity of adjoining lanes by restricting vehicle speeds. It may block all lanes in one direction, and completely block traffic in that direction. The maximum capacity of a traffic lane with vehicles moving at 20 mph is only 87% of its capacity at 30 mph. At 10 mph a lane has only about 50% of its 30-mph capacity. A minor accident which causes a reduction in speed can result in complete congestion when a facility is operating near its capacity.

• *Curbs and Lateral Clearances*—Any vertical member adjacent to a roadway constitutes a safety hazard and is an obstruction to the free movement of traffic, unless it is six feet removed from the pavement edge. High vertical curbs of the so-called non-mountable type fall within this category, and if they are required they also should be separated from the traveled way by six feet to have no effect on traffic, but if they are three or four feet away their effect will not be critical. A low sloping curb may be used adjacent to the roadway surface in conjunction with a high curb further removed.

• *Drainage*—The provision of side ditches, gutters and drainage structures sufficient to prevent mud and debris from washing onto or collecting on the roadway surface during storms, is a necessary safety measure. Such foreign materials constitute hazards within themselves by creating slippery pavement conditions, but of greater importance is the hazard created by drivers who, in attempting to avoid such materials, bring their vehicles into the paths of other vehicles. In the colder regions the formation of ice on pavements as a result of water collecting in poorly drained places presents a serious safety problem.

* On the Oakland Bay Bridge, for example, during the peak hour, when 6700 vehicles use the six-mile structure, an average of two vehicle breakdowns can be expected, which will seriously affect the traffic capacity of the bridge.

• *Highway Intersections*—To provide safe operation at intersections, on rural through roads carrying an average traffic of 5000 vehicles per day and over, the grades should preferably be separated at intersections with other major roads.

Chief among the reasons for safety violations at intersections is congestion. The driver whose patience is exhausted is here the dangerous operator. Aside from relief of congestion there are a number of measures that aid in minimizing hazards at intersections. Among these measures the following rank high:

Corner sight distances consistent with the operating speeds of traffic, with due consideration of the method of traffic control employed.

Safety islands for pedestrians at busy intersections where streets are wide and pedestrian traffic is heavy.

Separated turning lanes, especially on high-speed or moderately high-speed divided highways to enable turning vehicles to decelerate and stop, if necessary, clear of the lanes used by through traffic.

• *Railroad Grade Crossings*—All main line railroad grade crossings of highways which carry substantial traffic flows should be separated. Because of the cost and the pressures for other highway improvements, the elimination of crossing hazards by construction of separation structures will be delayed at many locations. Consequently, grade crossing protection should proceed rapidly. Particularly effective are the installations of the short-arm automatic gates. These have some obvious maintenance and cost advantages over the long-arm gate installations, and provide a barrier which experience has proven adequate. Though the short-arm gate and flashing signal is somewhat more expensive than the flashing signal installation alone, this type should be uniformly used for all main-line crossings at grade, regardless of the number of tracks. This position is reflected in the present policies of the Public Roads Administration.

• *Loading Recesses*—The destined function of practically all of our highway mileage, both new and old, is to provide service to all classes of traffic. The peculiar needs of commercial and mass transit vehicles, not only in their steady flow movements, but at their terminals, transfer points and roadside stops, require attention in shaping the physical features of the roadway. The frequent stopping of transit or commercial vehicles in the moving traffic stream is a serious traffic hazard. Wherever possible, and in all instances on new highways designed as routes for mass transit, proper facilities for transit vehicles off the through lanes for passenger loading and unloading should be provided. These roadways should be designed to expedite movements of the transit vehicle as well as those of the more numerous private passenger car. Through the provision of more attractive and convenient mass transportation, there is the possibility of shrinking our urban traffic problems to more moderate limits. Efficiently designed off-street loading bays and terminals for trucks serve a similar purpose, particularly in the central core of our cities where street space is wholly inadequate for the moving traffic.

• *Uniform Signs and Signals*—Traffic control devices, though relatively inexpensive accessories to street and highway design, are significant aids to safe highway operation. Well designed and located highway signs, signals and markings eliminate or relieve many of the elements of surprise that characterize certain combinations of design and traffic operation features. The planning of new highway facilities should always be accompanied by thought as to the traffic control, to hold restrictive measures to a minimum. Such preliminary considerations also offer certain correlative benefits in the joint planning of design and control elements on the new facility. The control will thus be tailored into the design at the most appropriate stage, and not left for piecemeal application after completion of the construction. The Manual on Uniform Traffic Control Devices should be rigorously followed. The Manual has become the single legal standard for use on all Federal aid projects.

• *Speed Control*—Reasonable speed is a necessary element of efficient highway transportation, yet speed is so frequently pointed to as a traffic accident cause that the dictum has wide acceptance that traffic accidents and higher speeds go hand in hand, and that there can be no one facility that possesses the characteristics of speed and safety. Numerous attempts to relate speed and accidents have had but meager success. Speed definitely increases the severity of accidents, and it has been demonstrated from studies in New York, New Jersey and Connecticut that fast drivers are guilty of more traffic violations and are involved in more accidents than those who operate at more moderate speeds. But we also find that our modern highways with excellent safety records are accommodating traffic speeds definitely above those found on routes of inferior design.

The answer is certain. The newer facilities have been purposely planned to meet the higher speed demand, and are distinguished by uniformity in those design features that relate to safe accommodation of faster-moving traffic.

Safe vehicle speeds thus depend in large measure on characteristics of the roadway. With approximately 400,000,000,000 vehicle-miles of travel annually, it can hardly be expected that police activity on speed law enforcement will be effective for more than a small fraction of this total. Speed controls, where applied, must be adapted to the circumstances. On our highway systems, both urban and rural, there is a wide range of ability to accommodate speed. This is true not only for the nation but for any state, or for any appreciable length of highway within a given state. Thus, the establishment of a uniform legal speed limit for rural and urban areas is not a solution. Such a policy is unsound. A limit set at the maximum safe speed for the poorest section of highway is obviously an invitation to disregard the law. Thirty-seven of the states now exercise the authority to post speed limits differing from the speed that has been set as a general maximum. The rural state-wide day-time limits range from 25 mph in one state to no limit in 14 states. Of the 29 states having general limits above 50 mph, all but four are using the device of zoning to encourage judicious use of the highway with respect to speed. Much more needs to be known about the principles of successful zoning,

but sufficient study has been given to determine that the signing must be realistic and possess considerable self-enforcing value. The establishment of frequent unwarrantedly low limits breaks respect for the entire zoning device, which is reflected in abuses of other essential traffic regulatory measures. (Refer to Table 2 for safe speeds on curves.)

Rural Statewide Speed Limit	No. of States	No. of States with Rural Speed Zoning Authority
No limit	14	10
60 mph	8	8
55 mph	7	7
50 mph	10	7
45 mph	4	3
40 mph	2	0
35 mph	2	2
25 mph	1	0
	48	37

• *Efficient Operating Grades for Trucks*—Table 3 shows the distance that light-powered trucks with gross loads of 30,000 lb, and medium-powered trucks with gross loads of 40,000 lb, can go up various grades before their speeds are lowered to 30 mph.

Gross loads of 40,000 lb on medium-powered trucks will probably not occur with sufficient frequency on most of our main rural highways to justify basing the road design on these vehicles alone. Light-powered trucks with gross loads of 30,000 lb will occur, however, with sufficient frequency on most main highways to affect seriously the operation of passenger vehicles on the highway unless they are considered when selecting the alignment and other design features of the road. It will be noted that the length of grade that reduces the speed to 30 mph is approximately the same for the lighter-powered trucks with the gross loads of 30,000 lb as for the medium-powered trucks with gross loads of 40,000 lb.

Table 3—Efficient Operating Grades for Trucks
Distance from bottom of grade where trucks would be reduced to 30 mph.
This schedule assumes an approach speed of 40 mph. Bad alignment, weak or narrow bridges, or other hazardous conditions at the bottom of the hill would make these speeds unsafe.

Light-powered trucks with gross loads of 30,000 lb

Grade	Distance from bottom of grade	Vertical climb from bottom of grade
%	Ft	Ft
2	2000	40
3	1090	33
4	760	30
5	570	29
6	470	28
7	400	28
8	325	26
Medium-powered trucks with gross loads of 40,000 lb		
2	1780	36
3	1035	31
4	740	30
5	550	28
6	450	27
7	390	27
8	320	26

A third lane on the uphill side will prevent the slow-moving trucks from unduly interfering with other traffic if the third lane is started at the distance from the bottom of the grade, as shown by the table. In certain types of terrain, however, especially where the road is located on the side of a steep hill or mountain, it may be impractical to provide an additional lane. Since the problem must be met on main routes, there are the alternatives of improved alignment for routes of light travel, or a new one-way, two-lane roadway on a separate location. In the latter case the old plus the new roadway would provide two lanes in each direction.

Far too little attention is given the fact that farm production is moving to the markets and to the railroads in trucks. In a constantly increasing degree the secondary or farm to market roads must be designed for truck opertion, and efficient, safe operation requires low gradients. The lowest unit cost item in road construction today is earth excavation, and there is no reasonable excuse to neglect the economy that will accrue to the farms by designing farm to market roads requiring additional excavation to provide low grades and good alignment.

From the angle of safety only, the most serious result of grades is the restricted sight distance at the crest, or of the erroneous design policy, quite generally practiced, of introducing short sight distance curves to lower the per cent of gradient.

Less-than-Traffic-Speed Driver

On week ends and holidays the most fervent anathemas of other drivers are directed toward the driver who fails to maintain the average traffic speed. This attitude mistakes the effect for the cause. The collection of a queue of cars with frustrated drivers behind a car moving slower than the average traffic speed is a sure indication of an overloaded highway. The same conditions apply as in the case of the slow-moving truck. The fault is the highway, not the slow driver. Too narrow traffic lanes and too restricted sight distances are the most common defects. The slow driver is not likely to disappear from the roads; the remedy lies in eliminating his accident potential by improved road design.

Highway Capacities

At the present time our main highways carry about 20% commercial traffic. During peak hours, however, commercial vehicles are generally in the neighborhood of 10% of the total traffic. In rural areas, two-thirds of the traffic is generally in one direction during the peak hours. In urban areas, the distribution by direction will generally vary from two-thirds in one direction in the outlying areas to an equal distribution each way in the central business districts. It is generally not feasible to obtain a perfect alignment having no sight distance restrictions on two-lane highways. Even in flat terrain it is difficult to obtain more than 80 or 90% of the road with a sight distance over 1500 ft, and in rolling terrain it is difficult to obtain more than 60% of the road with a sight distance over 1500 ft. The total hourly capacities for two- and

four-lane highways in rural and urban areas are for these average conditions, as shown by Table 4.

When relating the hourly design capacities to annual traffic volumes, fluctuation in traffic flow must be considered. Comprehensive studies of the fluctuation in traffic flow on rural highways show that the traffic density somewhere between the 30th to the 50th highest hourly traffic volumes of the year should be selected for design purposes. On the average rural highway the 30th highest hour of the year is about 15% of the average 24-hr traffic volume. In urban areas it averages about 12% of the annual average traffic volume. Table 5 shows the annual traffic volumes that can be used for design purposes at locations where there is the average fluctuation in traffic flow. Values as much as 30% higher or lower than these may be applicable to a specific project, depending on the seasonal, daily and hourly fluctuation, and the distribution of peak-hour traffic by directions.

A four-lane expressway of modern design with controlled access will accommodate as much traffic at approximately twice the average speed as

(1) Five ordinary city streets, each 40 ft in width with parking prohibited.
(2) Eight ordinary city streets each 42 ft wide with parking on both sides.
(3) Five ordinary city streets each 68 ft wide with parking on both sides.
(4) About three ordinary city streets each 68 ft wide with parking prohibited.

By "ordinary city streets" is meant those that have the average amount of left-turning movements and pedestrian interference prevalent in downtown areas.

Brakes

The hazardous conditions created by too short spacing between cars following in the same lane are emphasized by the studies of brake performance. Safe vehicle performance depends to a greater degree upon adequate, well maintained brakes than upon any other single element of vehicle design. Likewise, the brakes betray most surely driver or owner failures and neglect. Studies by the Public Roads Administration just before the war disclosed that over 40% of the passenger cars tested on the highway had zero pedal reserve. That is, the pedal was flat on the floor board after an emergency stop from 20 mph.

Brakes are a common alibi in many accidents, sometimes the true cause, but more often not. If the brakes fail, the responsibility lies usually with the driver. He has not maintained them properly.

The widely distributed studies of brake performance show that the condition existing in 1942 was not a rosy one. It is probably worse today. Only 62% of the passenger cars, 18% of the two-axle trucks, and 3% of the three-axle combination units could stop in 30 ft or less from a speed of 20 mph.

There is abundant confirmation that the braking systems of passenger cars and especially commercial vehicles are too commonly poorly maintained or grossly inadequate. An analysis of the results indicates that this level of performance can be greatly improved. Passenger cars and two-axle trucks can be made to stop from 20 mph in 30 ft or less. The combination units now on the road may not be able to do that well, considering the lag that exists between the time that the pedal is touched until the brake shoes actually contact the drums. However, it is certain that with proper maintenance of well designed braking systems, a much better showing can be expected. It is heartening, in this respect, to read that the Pennsylvania Motor Truck Association's Engineering Subcommittee has been able to stop a 62,000-lb, two-axle tractor and tandem axle semi-trailer in an average distance of 27 ft, 9 in. There is every indication that the automotive engineers who cooperated in the tests have succeeded in reducing to a marked degree the inherent brake lag.

The tests of vehicles as they are now operating on the roads clearly show that the proper maintenance of brakes is not as yet being generally accomplished, and that a more stringent enforcement policy is necessary.

The importance of brakes in relation to driver behavior is emphasized by Table 6 showing distance spacing and time interval between cars traveling in the same lane. If the driver behind has instant perception time, which is impossible, and the average reaction time of 3/4 sec, if his speed is only 30 mph, he has 2/3 sec for his brake to stop his car if the car ahead stops suddenly. Under such typical circumstances, when an accident occurs do the driver's brakes fail to work, or does the driver fail

Table 4—Hourly Design Capacities for Express Highways[1]

Type of highway	Rural areas[2]		Urban areas[3]	
	Flat Terrain[4]	Rolling Terrain[5]	Flat Terrain	Rolling Terrain
2-lane	600	500	....	....
4-lane	2800	2500	4550	3850

[1] Based on 10% commercial vehicles during the peak hours.
[2] Based on 2/3 of traffic in one direction and an operating speed of 50 mph.
[3] Based on 60% of traffic in one direction and an operating speed of 35 to 40 mph.
[4] Based on sight distance of at least 1500 ft on 80% of the 2-lane highways.
[5] Based on sight distance of at least 1500 ft on 60% of the 2-lane highways.

Table 5—Annual Average 24-hr Design Capacities for Express Highways (For average conditions)[1]

Type of highway	Rural areas[2]		Urban areas[3]	
	Flat Terrain	Rolling Terrain	Flat Terrain	Rolling Terrain
2-lane	4,000	3,300	.....	.....
4-lane	18,700	16,700	38,000	32,000

[1] Based on the conditions shown in Table 4.
[2] Based on a 30th highest hour of 15% of the annual average traffic.
[3] Based on a 30th highest hour of 12% of the annual average traffic.

Table 6—Average spacing between vehicles following other vehicles closely in the same lane at the same speed. (Spacing measured from the rear bumper of one car to the front bumper of the following car)

Speed		2-lane highway		4-lane divided highway			
				Left lane		Right lane	
mph	fps	ft	sec	ft	sec	ft	sec
10	14.7	30	2.04	...	...	...	...
20	29.3	42	1.43	...	...	...	...
30	44.0	62	1.41	60	1.36	80	1.82
40	58.7	90	1.53	77	1.31	105	1.79
50	73.4	122	1.66	107	1.46	130	1.77
60	88.0	162	1.84	139	1.58	156	1.77

to work the brakes? The answer is one major reason why insurance rates are going up.

Paradox of Driver Behavior

"We know so much about roads that is not so," has long handicapped correct thinking. We do know now much of driver behavior that without positive proof we think could not be true. For example, the relationships of accident frequency and accident potentials with the details of highway design have been described. The accident rate on two-lane rural highways carrying less than 1000 vehicles per day is approximately half that on similar highways where the volume is in the 8000 or over vehicles per day range. That is, on over-loaded highways or under-designed highways the accident rate increases with traffic volume. On such highways, we would logically think drivers would become more careful. Paradoxically, driver behavior becomes worse as the road becomes more inadequate to carry safely the traffic volume. Under conditions where the driver should become more responsible he becomes less so. Contrary-wise, evidence supports the conclusion that as the standard of design is raised, driver performance becomes more responsible. This observation of driver behavior undoubtedly reflects the ability of the average mind and nerves to function more safely if tension beyond necessary alertness is relieved, and apprehension is absent.

Here is the record of traffic operation that has emerged from the studies on the Pentagon System of roads over the past six years. The system was designed and built by Public Roads to serve an estimated population of 50,000 office workers in the new defense establishments, all of which were transferred almost over night across the Potomac River to a previously unoccupied area in Virginia. The problem was to move the major part of this population in and out daily by motor vehicle over the existing three Potomac River bridges.

Excluding the traffic over Memorial Bridge which uses Lee Boulevard, and other traffic which does not actually traverse a portion of the 17 miles of through routes, it is estimated that there are now 85,000 trips per day. Including the traffic on roads immediately tributary to the system, daily about 110,000 vehicles use these roadways. This is a conservative figure since the three bridges which the system serves are now carrying an average traffic of more than 139,000 vehicles per day and a peak month traffic of 149,500 vehicles per day. The system produces about 67 million vehicle-miles of travel per year. In the six-year period, five fatalities have resulted from this operation, three of whom were pedestrians. Only one fatality was caused by a vehicle traveling at a relatively high rate of speed, leaving the road and overturning. For this six-year period the accident rate is 1.5 fatilities per 100,000,000 vehicle-miles. In this experience lies the assurance of what can be accomplished through safe road design, but the record of driver behavior is the astonishing feature.

During the war there was a 35 mph speed limit on both the Pentagon network and Shirley Highway. The 35 mph speed signs were not removed until several months after the war. Prior to their removal, speed studies were conducted at several points on the network and on the Shirley Highway. These studies were repeated after changing the 35 mph signs to speed limit signs of 40 mph on the network and 50 mph on the Shirley Highway.

Changing the speed limit on the network from 35 to 40 mph had no effect on the average speed but reduced the number of vehicles traveling over 50 mph by 11% and those going over 40 mph by 20%. Changing the signs on the Shirley Highway from 35 to 50 mph reduced the number of vehicles traveling over 50 mph by 32%.

On the through routes of the Pentagon network, where there are no traffic police, no traffic control lights and no enforcement of the 40 mph posted speed limit, the average speed is 37.6 mph, and 12% of the vehicles exceed 45 mph. On Lee Boulevard, where safe speeds are much lower and the posted speed limit of 35 mph is enforced by frequent patrolling by traffic police, the average speed during light traffic volumes is 37.8 mph, with 11% of the vehicles exceeding 45 mph and 36% exceeding 40 mph. Thus on the network where drivers can legally maintain reasonable speeds at all times, they travel no faster without enforcement than they do on Lee Boulevard where safe speeds are not as high and the normal enforcement is present. Furthermore, three times as high a percentage of the drivers exceed a 5 mph tolerance of the posted limit on Lee Boulevard as on the Pentagon network.

The present volume is 800 per lane at locations where three lanes are available for movement in one direction. At the principal mixing lanes, a flow of 1150 vehicles per lane occurs where four lanes are available for one-direction movement. The principal mixing lanes are now loaded to their possible capacity at certain peak periods. Other points on the network are loaded to approximately two-thirds of their practical safe capacities. All three bridges are loaded beyond their practical, safe capacities, and at times the demand actually exceeds the possible capacity of the bridges with their present approaches. The condition will be relieved materially by the completion of the two four-lane one-way bridges now under construction.

Highway System Planning

In harmony with the premise that roads must be designed on a basis of driver behavior, is the relatively new technique of planning the system of arterial roads to serve the heavy flow lines of metropolitan areas on the basis of origin and destination

surveys. These surveys disclose the desire lines of major travel. The pattern which emerges is that of a wheel, usually somewhat distorted in shape, but essentially providing radial lines from the urban center which are joined by concentric circles at spaced distances from the center. The concept has the two major objectives of providing free flowing arterial routes in and out of the center, and of separating through, longer-distance traffic from local vehicle and pedestrian interferences. Also, such a plan will keep a high percentage of the total traffic out of the more congested center of the city. Driver behavior can be relied upon to exercise a high selectivity of route if the facilities provide a choice. Under such circumstances the driver will choose the route that will give him the most direct access to his destination, but at the same time will give him the shortest distance of travel through the more congested downtown streets. The Pentagon system serves three bridges across the Potomac River into the downtown streets of Washington. These bridges are interconnected by the system, and the driver from the Virginia suburban districts had, until the bridges became so congested as they are today, a choice among the bridges of that route which would require him to travel the least distance on, or would keep him off, the downtown, congested city streets. The degree to which he accomplished this purpose without any imposed controls is amazing, and is shown by the following record:

Comparison of a distribution of the traffic between the three Potomac River, Washington, bridges calculated on an assumed usage of the shortest route between origin and destination of trips with actual distributions observed on Aug. 16, 1944, and throughout the year Sept. 1, 1943, to Aug. 31, 1944

Bridge	Actual distribution on Aug. 16, 1944	Actual distribution Sept. 1, 1943 to Aug. 31, 1944	Calculated distribution if shortest routes were used
	Per cent	Per cent	Per cent
Highway Bridge	41.8	42.6	40.2
Memorial Bridge	33.0	31.5	32.7
Key Bridge	25.2	25.9	27.1
Total	100.0	100.0	100.0

The above listing shows the actual distribution is representative of the free choice of traffic between origins and destinations during a period when the traffic volumes were relatively low and there was not sufficient congestion on the bridges to alter the desired usage.

A study of the origins and destinations of traffic using the three bridges indicates that the slight percentage differences between the shortest routes and the actual routes used, probably resulted from traffic dividing itself in its use of the three bridges to the one that would permit the shortest travel distance on the Washington central city streets.

Finally, this discussion is directed to the essentials of today's program of highway improvement. Since 1934—nearly one and one-half decades—the state-wide planning surveys have been accumulating the facts of the amount and characteristics of the traffic use of our highways. State by state, undoubtedly more is known about the highways, their use and their needs, than about any other major public undertaking. Until recently this wealth of material had not been generally analyzed and organized to serve its most important purpose as conceived when the surveys were started. In 1945 the California Legislature, recognizing the need for a long-range highway improvement plan, established a study committee to organize the available material and to secure new data necessary to bring together a complete engineering and economic report. The completion of the report, the legislative recommendations, the legislative debate and the adoption of the major recommendations, are now a part of the State's highway history. California has a well-rounded, long-term modern highway improvement program. With this successful guide many other States have now in active operation legislative study committees, which, with the competent technical assistance of the Automotive Safety Foundation, are maturing long-range programs of comparable caliber. The planning is designed to serve both economic needs and safety of use. Since the future reduction in the highway fatality toll, as has been shown, will depend so largely upon safer roads, no effort by the Foundation can result in a greater contribution to highway safety.

There are also implications of vehicle design that can be well heeded. For example, it is certain the driver needs to have a better sight of the right-hand edge of the road. Also, that protective bumpers, front and rear, capable of absorbing shock, be installed in place of expensive grillage which is going to suffer more in the future than in the past. Roads cannot be designed to prevent this type of accident, which is likely to involve a series of cars. Also, is it not time to forget the emphasis on minor overspeeds of the decent driver and concentrate on the driver who by his behavior creates accident hazards? The driver who passes in a no-passing zone, who parks his vehicle on the pavement and who crowds the other fellow's lane is a killer. Why not take him off the road?

The purely routine speed checking is as futile and wasteful of enforcement officers' time and ability as is their detail to check on overtime parking, both of which only result in congestion in the traffic courts on matters having a minimum relation to real traffic safety. We need the time of the traffic officers and of the courts to take the dangerous driver off the roads. Only a very small percentage of drivers habitually disregard the rules of safe driving.

This matter of driver behavior goes very deep. It involves a psychology that may well be inherent in a people who have been, and are capable of, building and running the outstanding democracy of the world. It is the essence of the spirit of freedom which revolts against unfair or unreasonable restrictions but which is tempered in the large majority to support of the public welfare. So it seems reasonable to accept the pattern established by the behavior of the decent majority and deny the freedom of the road to the violator of this pattern. Safety of the highways is—like democracy—a matter of cooperation and coordination.

ATOMIC-POWERED Hurls Challenge at

BASED ON PAPER* BY

Andrew Kalitinsky

Chief Engineer, NEPA Division,
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(This paper will be printed in full in SAE Quarterly Transactions)

ATOMIC energy bids fair to fuel future aircraft because it packs the double punch of high performance and long range. Turbine and jet type engines running on nuclear fuels will power non-stop, 'round-the-world airplanes of tomorrow, but not before remaining engineering obstacles are hurdled.

Beauty of atomic fuel, from an aircraft propulsion standpoint, is that it is a high concentration of energy in a small mass. You can expect long range from such a fuel with a heating value of 40 billion Btu per lb. Gasoline also gives you range if you don't demand speed. But the combination of speed and range is the attraction found only in atomic propulsion.

* Paper "Atomic Power for Aircraft Propulsion," was presented at SAE Detroit Section, Feb. 2, 1948, and SAE Metropolitan Section, New York, June 16, 1948.

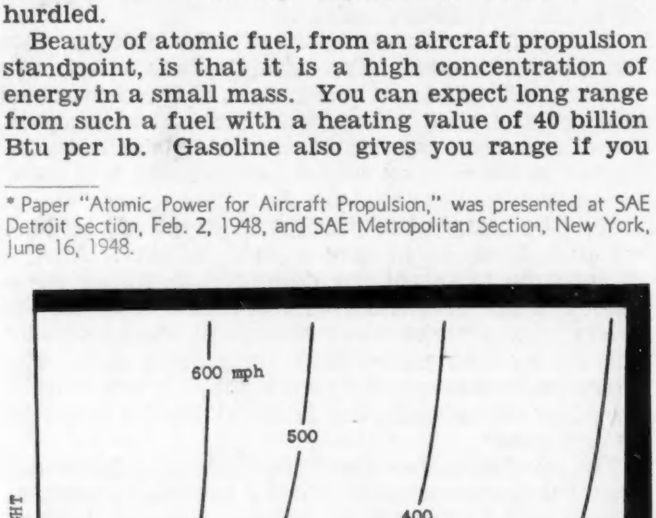

Fig. 1—As speed of chemically-fueled aircraft increases, their range decreases, this chart shows. But for a given speed, there is a point beyond which you cannot increase the range no matter how light you make the airplane

Chemically-fueled airplanes face performance limitations of the kind shown in Fig. 1. For a given flight speed, required gross weight increases with range since fuel needs go up. At a given range the curve becomes practically vertical. You can't by-pass this barrier because for a given speed, airplane range can't be increased no matter how large the airplane.

As speed increases, so does gross weight for a given range. And more important, maximum range possible decreases as speed increases. While aerodynamic and structural efficiency of the airplane vary, the basic shape of these curves remain the same for any chemically-fueled machine.

A horizontal line in Fig. 1 would represent the atomic-powered airplane since range does not affect its gross weight. Beyond the point where this line intersects the curve for the chemically-fueled airplane of the same speed, the nuclear-fueled airplane will be lighter. More important, for ranges greater than those where the curve for conventional aircraft approaches the vertical, the atomic-powered airplane is the only possible one.

Comparing extremes, a supersonic airplane exhausts its fuel supply in a few minutes; with atomic fuel it could keep flying for a long time since the fuel supply remains nearly constant.

Atomic Engine Types

Several basic types of powerplants lend themselves to adaptation for atomic energy to power aircraft. They are shown in Fig. 2. All are fission powerplants since fission energy is released predominantly in the form of heat. Although some thought has been given to direct production of electricity from the fission process, there is no practical way of doing it at present.

First kind of thermal engine in Fig. 2 that may be used with atomic energy is the closed-cycle turbine. It can be a steam or mercury turbine. Steam is generated in the nuclear reactor by the heat released there. Thus the reactor replaces the boiler of a conventional powerplant.

The steam expands through the turbine which

PLANE Engineers

drives a propeller. Next it is condensed in an air-cooled condenser and forced back into the boiler-reactor by a feed pump. Since this type of powerplant requires both a propeller and aircooled condenser, it limits airplane speed.

Second possible application of atomic energy is to a turbojet. Here a nuclear reactor replaces the combustion chamber of the conventional turbojet. Air is compressed in the compressor, forced through the reactor, and there heated by convection instead of by combustion of fuel.

The air then expands partially in the turbine, enough to provide power for driving the compressor. It completes expansion in the jet nozzle where it creates propulsive thrust. This type of engine is well-suited to high-speed airplanes.

Third type engine feasible for atomic energy conversion, the ramjet, is the simplest kind of powerplant conceivable—on paper only. Air enters the diffuser at the engine front end and is compressed by forward speed of the airplane. It then passes through the nuclear reactor and heated to a high temperature; then through the exhaust nozzle where it expands and gets a high speed that provides the propulsive thrust.

The ramjet requires high flight speed to function at all. It becomes really effective at speeds in the supersonic region. It also wants very high air temperatures, considerably higher than those for the turbojet. At the same time the ramjet is sensitive to pressure drops stemming from internal resistance of the reactor or combustion chamber. But appreciable pressure drops is the price you pay for good heat-transfer conditions.

Thus the ramjet is not quite the simple problem it seems to be at first glance.

The rocket also can be adapted to nuclear energy, as shown in Fig. 2. Here a propellant—such as liquid hydrogen—is pumped out of the tank and through the reactor where it is vaporized and heated to a high temperature. It then escapes at high velocity through the exhaust nozzle. Recoil of the escaping propellant drives the rocket, so that it does not depend on atmospheric air to function. For this reason it can operate outside the earth's atmosphere.

Use of nuclear energy for rockets begs the ques-

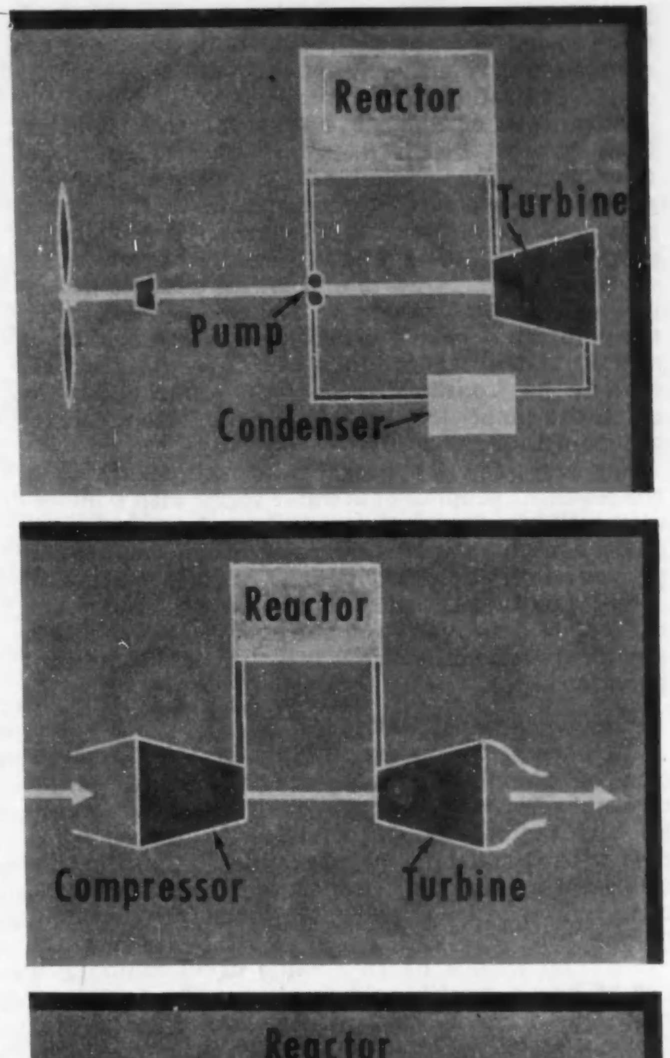

Fig. 2—Atomic energy can be harnessed to aircraft by these types of powerplants. From top to bottom, they are: steam turbine, turbojet, ramjet, and rocket

tion of its advantages; rocket endurance is limited since it can operate until propellant supply is exhausted, regardless of practically unlimited supply of energy in the reactor.

Advantage of nuclear energy for rockets stems from this relationship: Propellant specific thrust (pounds of thrust available from each pound of propellant per second) is proportional to the square root of absolute propellant temperature divided by propellant molecular weight. In other words, highest possible temperature and lowest possible molecular weight are desired. In a chemical rocket high temperature normally is produced by combustion of a fuel and oxidizer; products of combustion then are used as the propellant. Since the propellant is the combination of at least two atoms, its molecular weight will be fairly high.

For example, if hydrogen and oxygen are used, the resulting propellant is water vapor with a molecular weight of 18. But using nuclear energy to get the high temperature requires no combustion process; a very light propellant—like hydrogen, with a molecular weight of 2—can be used. Since the ratio of 18 and 2 is 9, and the square root of 9 is 3, specific impulse of pure hydrogen is three times that of water vapor.

Hampered by Heat

High temperatures used hinder practical realization of atomic powerplants for aircraft. High thermal efficiency is not the chief reason for wanting high temperatures in a nuclear engine, as is the case with chemically-fueled engines. Specific fuel consumption, inversely proportional to thermal efficiency, is vitally important in the conventional engine.

But fuel with a heating value of 40 billion Btu per lb has a vanishingly small specific fuel consumption from a performance standpoint; and thermal efficiency in itself is not a primary objective. High performance is. And high performance calls for high operating temperatures.

For example, a high thrust per pound of airflow per second is required for turbojets in high-speed airplanes. This calls for high energy input for each pound of air and, therefore, high air temperature.

The heat-transfer problem aggravates temperature difficulties. Actually we are taking a long step backward along the road of light-weight engine development. Great advance in light-weight design making the car and airplane possible was learning how to avoid transferring heat through walls . . . the advent of internal combustion.

The nuclear engine generates heat in the solid portions of the reactor which must be transferred to the working fluid through heat-transfer surfaces. Internal surfaces of the reactor must be at a higher temperature than the working fluid since heat must flow from reactor to fluid; and it can only flow if there is a positive temperature difference.

This differs from an internal combustion engine. A passenger car powerplant attains cycle temperatures of 4000F while internal temperatures can be kept down to 500F by external cooling. But as a compensating advantage the reactor has no moving parts; reactor elements are not subjected to high dynamic stresses as are pistons, valves, and turbine buckets.

Atomic Energy Made Simple

Since Hiroshima countless physicists, chemists, and scientists have tried their hands at laying open the mysteries of nuclear fission for the millions. Kalitinsky's introduction to atomic physics, in his complete paper appearing in the January, 1949, issue of SAE Quarterly Transactions, ranks with the best of such "atomic primers," according to leading engineers who heard it presented to SAE's Detroit and Metropolitan Sections.

Kalitinsky starts his explanation of atomic energy with a look into the structure of the building blocks that make up every object we touch and see—the atom. He then progresses through a disclosure of the tremendous energies involved and tells about the chain reaction that sustains the release of this energy.

Complex phenomena become simple when Kalitinsky uses analogies of everyday concepts. The paper in SAE Quarterly Transactions, on which this article is based, also reveals the engineering problems faced in building atomic power-generating plants.

Metallurgically, atomic engine temperatures are not unreasonable, but engineering wise corrosion and weight pose more perplexing problems.

First, we must protect uranium in the reactor against corrosion by the working fluid, and conversely, prevent escape of radioactive fission products from the reactor into the working fluid. This is a problem of diffusion; diffusion rates generally go up with increasing temperature. Developing adequate canning for high-temperature reactor elements holds the key to corrosion prevention.

As in any aircraft job, weight is another crucial problem. With an atomic engine large amounts of energy must be used to stop radiations emitted during the fission process. Comparison with a conventional airplane can help visualize the magnitude of weights alloted to shielding.

Nuclear Engine Components

Three major items comprise weight of the propulsion system—the powerplant proper, the fuel, and the fuel tanks. In a nuclear aircraft these correspond to (1) the engine (compressor-turbine assembly in a turbojet), (2) the nuclear reactor, and (3) the shielding.

The nuclear installation engine component will weigh about the same as a conventional powerplant of the same horsepower or thrust rating. Weight of reactor and shielding is equivalent to fuel and fuel tank weight in a chemically-fueled aircraft. Percentage of airplane gross weight that can be al-

lotted to fuel and fuel tanks—or reactor and shielding—depends chiefly on structural refinement of the airplane.

It represents a very high percentage of gross weight—in some cases well over 50 tons—in present-day long-range airplanes. Obviously the atomic-powered airplane and the atomic-powered automobile pose problems totally unrelated, although both have been mentioned in the same breath in atomic energy discussions.

Not only is absolute weight of the shielded reactor important; we must also consider specific weight (weight per pound of thrust produced by the powerplant). We saw how shielded reactor weight ties in with gross weight of the airplane by the airplane's structural efficiency. Aerodynamic efficiency of the airplane—ratio of lift to drag—ties in the required powerplant thrust with airplane gross weight. Required lift equals gross weight while resultant drag must be overcome by powerplant thrust.

Combining these relationships produces a formula that links powerplant performance to aerodynamic and structural characteristics of the airplane. The formula: Specific weight of the reactor must be less than, or equal to, the lift-to-drag ratio times the ratio of permissible reactor weight to airplane gross weight.

Two entirely separate variables influence shielding weight about equally. One is size of reactor core around which the shielding must be wrapped; the other, thickness of the shielding itself. More precisely this second item is mass-thickness, shield thickness times shield density, which must stop gamma rays and neutrons emitted by fission.

Weight-Saving Techniques Analyzed

Obvious way to reduce shielding weight is to make the reactor small. But this means releasing energy at a high rate in a small volume. A nuclear reactor potentially can generate heat at a practically unlimited rate; but this heat must be conducted from the interior of the fuel rod to its surface. This signifies high thermal stresses. Then the heat must be transferred from the surface to the working fluid, which means high temperature differentials, high pressure drops, large internal areas, and all the other troubles associated with high power densities.

Additionally, the smaller the reactor, the larger the ratio if its surface area to its volume and the easier for neutrons to escape without causing new fissions. Thus a small reactor may require a larger investment in uranium to sustain the chain reaction—perhaps economically unsound.

As for shield mass-thickness, best materials for stopping a given type of radiation of a given energy are relatively well known. But nuclear reactors emit two major types of radiation: neutrons and gamma rays, each covering a wide spectrum of energies. Stopping both types at the same time is a problem. As they pass through the shield these radiations gradually change their character; fast neutrons slow down by successive collisions with nucleii of the shield; gamma rays are absorbed by electrons which emit softer X-rays.

A material good for stopping gamma rays may not be best for gamma rays and neutrons together. And a material suitable for the innermost part of the shield may not do for the outer layers. The field for weight-reduction through ingenious design is wide open.

In dealing with a relatively thick shielding surrounding a relatively small reactor, this apparent paradox holds true: For a given mass-thickness, the greater the density of shielding material, the lighter the shield. For example, if the density is doubled and shield thickness halved, shield volume is decreased by much more than a factor of two, and total weight reduced accordingly.

Shielding points up unusual aspects of nuclear engineering from the standpoint of conventional engine practice. For example, radiation absorption in matter generally follows an exponential law. This means that a given shielding thickness reduces radiation intensity by a fixed factor rather than by subtraction of a given amount. If 2 in. of lead reduces some radiations to one-tenth their original intensity, 4 in. of lead will reduce them to one-hundredth, and 6 in. to one-thousandth.

But radiation intensities from nuclear reactors must be reduced by factors of many billion before they are safe for the human body.

Here's another unusual twist that is not uncommon in nuclear engineering thinking. A good neutron reflector may turn back as many as 90% of the neutrons escaping from the reactor. But it is wrong to assume that this solves nine-tenths of the neutron shielding problem. More likely it represents only about 10% of the job. By the same token, preventing escape of seemingly small amounts of radiation through joints or seals in the shield is very important. Although a 1% leakage may seem negligible, it may be more than a million times the amount required to kill a person.

In addition to limitations imposed on selection of materials by their nuclear properties, effect of intense radiation on properties of the material must be considered. For example, exposing graphite to intense neutron radiation changes its electrical resistance, elasticity, and heat conductivity.

Sketching Atomic Plane

From a consideration of its engineering perplexities we certainly can say the atomic-powered airplane will be large. It will be unusual in that it has to be designed for equal landing and take-off weight since practically no fuel is used up in flight. Since radiation intensity decreases inversely proportional with the square of the distance, crews should be located as far as possible from the powerplant to save some shield weight.

Structural requirements will differ somewhat from those of conventional airplanes since the fuel load will be concentrated in one spot, the reactor, rather than widely distributed. But in this respect it may not differ too much from thin-winged, high-speed airplanes being developed without fuel tanks.

Atomic aircraft development is not an easy job. Don't expect to see an atomic-powered rocket taking off for the moon this year or next.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Fuel-Engine Studies Better

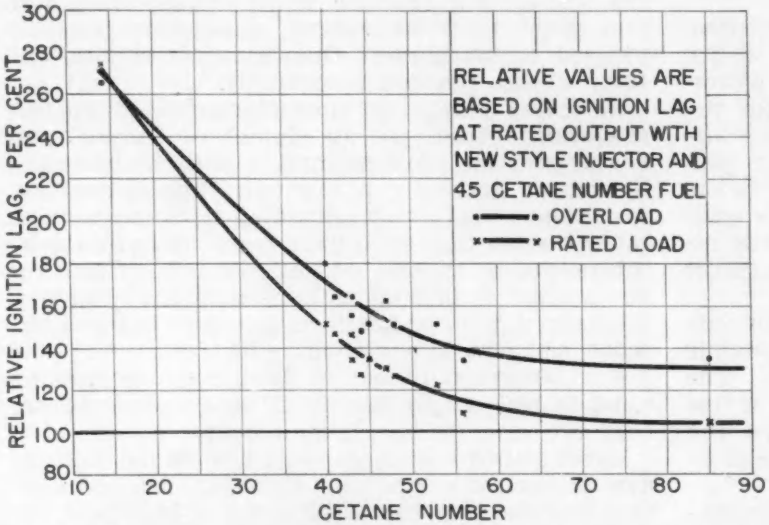

Fig. 1—Fuel tests evaluating effect of cetane number on ignition lag in the GM 567 locomotive diesel engine point up cetane number as an index of fuel ignition quality. These tests were run with the old-style injector

BASED ON PAPER* BY

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TESTING a wide variety of fuels showed that cetane number and heating value are the two fuel properties controlling cylinder pressure characteristics of the General Motors 567 railroad diesel engine. It also proved that changing injector design reduced the engine's cetane requirements and improved its operating efficiency.

Twelve different fuel oils—some regularly used in railroad diesels, others specially high or low cetane fuels, and several with special properties—were tested at 800 rpm, rated load and overload. Most significant disclosure of this program, with regard to fuel properties, was proof of validity of cetane number as an index of fuel ignition quality in the GM 567 engine. See Fig. 1.

Test results showed that ignition lag under constant engine conditions is a function of cetane number with an average deviation of 1½ cetane number. It is possible to predict quite accurately the cetane number of an unknown sample by the ignition lag in the GM 567 engine cylinder.

Fig. 2 shows that initial rate of pressure rise after start of combustion is a function of ignition lag and fuel heating value. Since the injector theoretically injects fuel at a constant rate, ignition lag controls amount of fuel accumulated during the lag period. Fuel heating value also can be associated readily with rate of energy released, since it determines the amount of energy in the volume of accumulated fuel.

As shown in Fig. 3, amplitude of the shock or sound wave set up in the gases in the combustion chamber is a function of initial rate of pressure rise. This is logical because the shock wave is set up by sudden release of energy from combustion of the accumulated fuel. Initial rate of pressure rise quantitatively indicates this energy release.

Taking Figs. 1, 2, and 3 as a whole reveals that cetane number controls both rate of pressure rise and shock wave amplitude by virtue of its control over ignition lag. Cetane number proved to be a valid indicator of fuel ignition quality in the GM 567 diesel and, therefore, of combustion roughness and shock.

The lowest cetane fuel tested, a coal tar gas oil rated at 14 cetane, did not support regular firing in the engine cylinders under rated load conditions and caused abnormally long ignition lag. This is indicated in Fig. 2 as Fuel 33; it deviates widely from average characteristics by the abnormal ignition lag. With this fuel the engine knocked audibly and the indicator cards showed shock wave amplitudes 30% of average peak pressure.

Since this group of tests was run at constant horsepower, it is interesting to note that maximum average cylinder pressure and time of occurrence of this are not functions of any fuel property. In fact, under constant horsepower conditions after initial combustion (discounting shock wave amplitude), all fuels burn the same. More recent cylinder pressure evaluations substantiate this finding.

Studying the frequency of shock wave amplitude indicates that after early-stage combustion roughness subsides, the wave assumes a set frequency. Gas wave vibrations confined in the combustion

*Paper "A Railroad Diesel Engine Improvement Based on Study of Combustion Phenomena and Diesel Fuel Properties," was presented at SAE National Tractor and Diesel Engine Meeting, Milwaukee, Sept. 7, 1948.

Railroad Diesel Performance

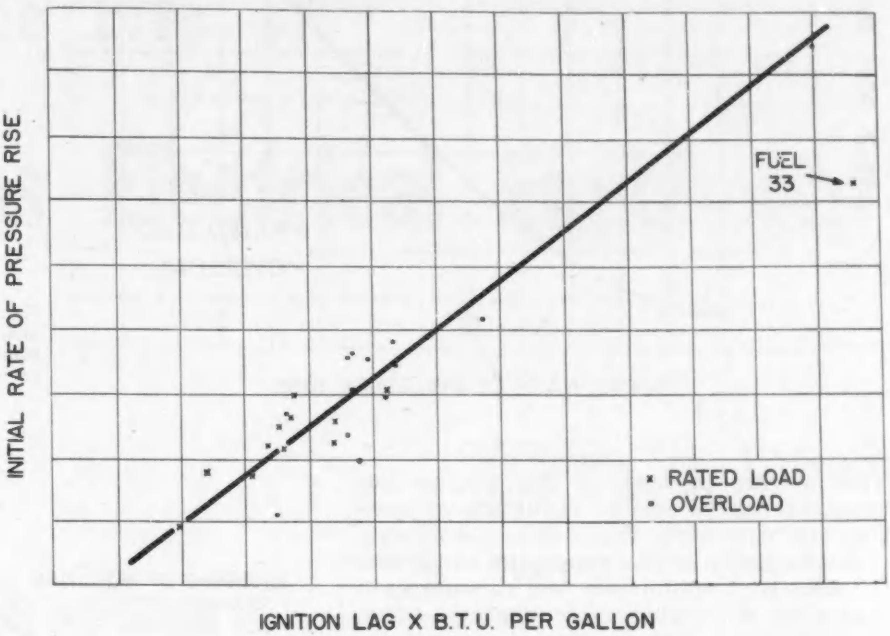


Fig. 2—Both ignition lag and fuel heat value control rate of cylinder pressure rise, show tests with the old injector. Fuel 33 was the lowest cetane fuel tested, exhibited unusually long ignition lag

chamber probably control this frequency.

These fuel property studies served as a basis for investigating factors that control the indicator card. This work led to redesign of the injector.

Tests with the standard injector indicated that retarding injection time could decrease pressure rise and peak pressure. But poor fuel economy and excessive smoke also accompanied these tests. Test runs were made with a special high-output injector to boost engine ratings by increasing the volume of fuel injected. At normal volumetric output these injectors also reduced ignition lag and peak pressure without adversely affecting fuel consumption.

Study of injector characteristics varied on these tests led to this conclusion: Injection was occurring too soon with production injectors; thus ignition lag was too long because of fuel being injected into too cool and too thin an atmosphere.

Since retarding injection with the standard injector produced poor fuel economy and excessive smoke, it was felt that combustion was incomplete at scavenging. To retard start of injection and still maintain end of injection at about the same time, it was necessary to increase injection rate. This was done by increasing injection plunger diameter. Timing arbitrarily was retarded at rated load condition by about 5 deg and end of injection left about the same.

Indicator cards made under idling conditions showed injection and combustion occurred so late in the cycle that fuel was burning after cylinder pressures and temperatures reached a maximum. To use maximum cylinder heat and pressure for combustion under idling, injection at idling was advanced from after top center to before top center.

A new injector was designed that achieved these desired conditions at rated load and idling.

To find whether injector design changes were right, tests were run on two fuels—one a high quality diesel fuel and the other a minimum acceptable quality fuel. These check runs proved the improvement in pressure characteristics. See Fig. 4. Peak pressure was reduced 10%.

As regards lag, a 40-cetane fuel with the new injector performed better than any fuel tested with the old injector under similar load conditions. See Fig. 5. Initial rate of pressure rise and shock wave amplitude decreased in proportion to shortening of ignition lag. The new design achieved a 2% improvement in fuel economy. It also noticeably reduced smoke density; formerly a light gray haze, it became almost invisible.

The redesigned injector reduced shock load, combustion roughness, and maximum cylinder pressure. This should help cut engine maintenance costs. Improved thermal efficiency brought about by the design change should reduce the railroad's fuel costs and maintenance costs as well.

An injector design check with two fuels showed the new injector significantly lowered the engine's cetane requirements. Ignition lag of a 30 cetane fuel with the new injector compares with ignition lag of a 50 cetane fuel using the old one. Actual limitations of cetane number now become involved in deposit-forming tendencies, light load operations, and other factors not within scope of these tests.

Correlation between ignition lag and cetane number were not as close as in tests with the old injector.

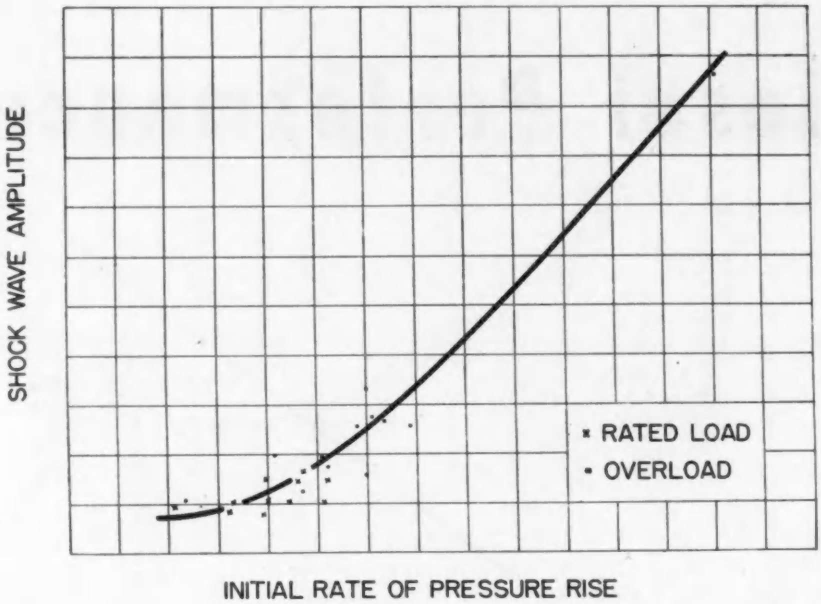
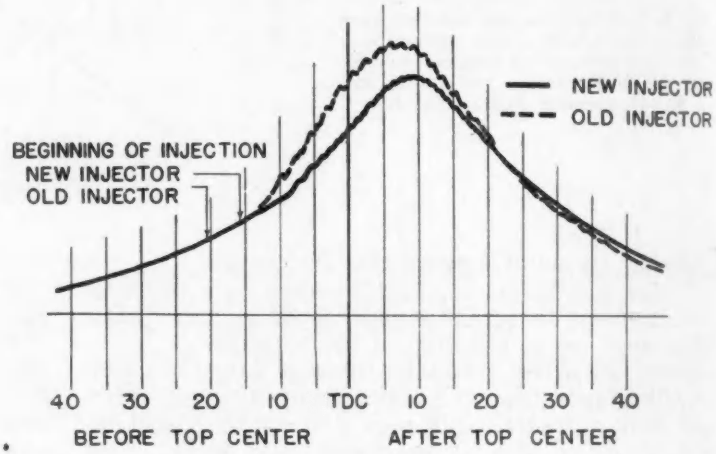


Fig. 3—Initial rate of pressure rise governs shock wave amplitude. This relationship is one of several significant ones established in studying links between fuel properties and engine operating characteristics of the GM 567 diesel

Fig. 4—Changing the injector design, comparison of indicator cards shows, lowered peak pressure 10%. New injection characteristics of the GM 567 diesel engine reduced both shock caused by lower cetane fuels and maximum cylinder loading



This is due to making the engine less cetane-sensitive and to reduction of ignition lag, with same limits of test accuracy.

Investigation of fuel properties confirmed the fact that volumetric fuel consumption decreases with increasing heating value. This tells the railroad customer that he gets more for his money by buying the heaviest fuel, on a gallon basis, compatible with maintenance costs. Specific fuel consumption by weight increases with fuel heating value on a volumetric basis.

It is significant that this increase in fuel consumption by weight doesn't indicate the efficiency with which the engine burns the fuel; it does show the fuel's heating value on a weight basis. For this reason don't condemn a fuel which on a comparative test has a higher specific fuel consumption by weight.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

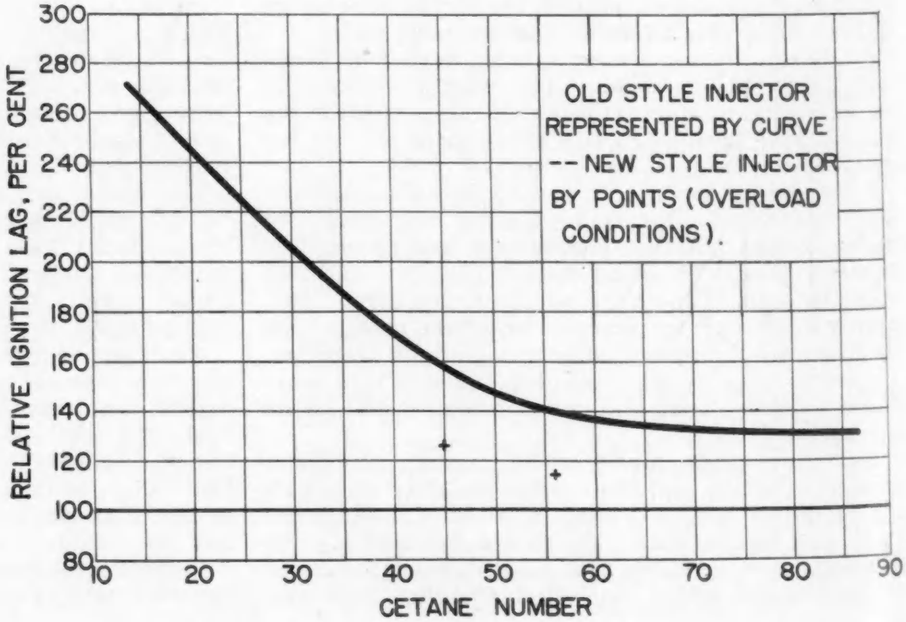


Fig. 5—By reducing ignition lag, the new injector saved 2% in fuel consumption

Design and Maintenance Prolong Service Life of

Truck & Bus Electrical Equipment

BASED ON PAPER* BY
William H. Foland
Delco-Remy Division, GMC

(This paper will be printed in full in SAE Quarterly Transactions)

NEW and better conceptions of jobs that electrical equipment must do in trucks and buses presage longer-lasting units—many of which are available, others well advanced in development. But proper maintenance keyed to service records still pays off in operating economy. That holds for batteries, cranking motors, ignition system, and generators and regulators.

The term "availability factor," is taking on added significance in evaluating battery performance and is influencing new designs. It stems from the requirement that truly heavy-duty batteries must deliver high discharge rates, yet maintain good working voltage. It means that a battery, within reasonable size and weight limits, must have all its working materials available to enter chemical activity.

New designs are emphasizing high porosity separators allowing free transfer of electrolyte so it can enter into reaction as completely as possible. Second feature aimed for is increased plate area to present more surface of active plate material to the reaction.

A battery's quality now is measured by its ability to deliver a high discharge rate at near its rated voltage and to accept a high rate charge without a great increase in charging voltage. This departs somewhat from the old standard of judging a battery solely on its ability to deliver a small output over a 20-hr period.

Improved plates and separators having durability in the dry state permit dry batteries to be placed in immediate service after filling. These dry-charged batteries actually can deliver 75 to 80% of normal rated capacity immediately with no boosting or cycling.

Because the cranking motor's job depends so much on engine requirements and battery performance, its design must consider more than components of just the isolated unit. Battery "availability factor" is one such important influence, which shows up when comparing cranking motor performance with different capacity engines.

Fig. 1 charts one motor cranking one engine at a given temperature. With the 17-plate battery, the

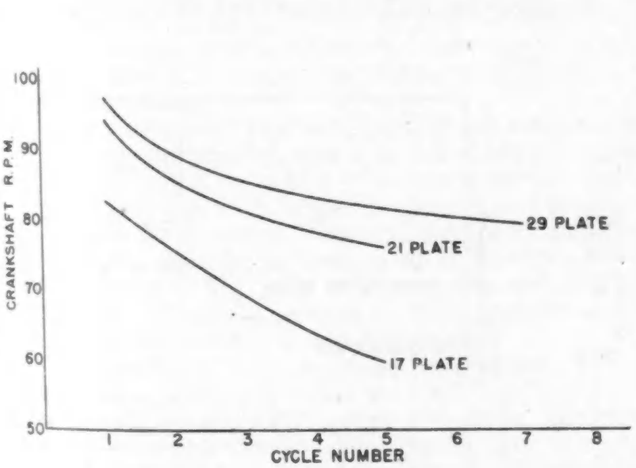


Fig. 1—Performance of a cranking motor depends largely on capacity of the battery used, this chart shows. In collecting these data, one cranking motor on one diesel engine was used with three different 12-v batteries. Speed was taken after 10 sec of each cycle. Each cycle consists of 30 sec cranking and 2 min rest

* Paper "Heavy-Duty Electrical Equipment Service and Maintenance," was presented at SAE National West Coast Meeting, San Francisco, Aug. 18, 1948.

motor cranks the engine at less than 60 rpm after five 30-sec starts. The 21-plate battery enabled the motor to crank develop cranking speed of 77 rpm after five 30-sec cycles; but the 29-plate battery kept cranking speed up to about 80 rpm for seven 30-sec cycles.

Many of the ignition system mysteries haunting designers as well as fleet operators are being dispelled. Some new features solving old problems are:

1. Oil-filled condensers which give vastly improved service life by eliminating breathing action that permitted moisture to contaminate interior insulation.
2. Oil-filled ignition coils give absolute hermetic sealing and improved cooling due to convection circulation of oil.
3. Dust-sealed distributors with greatly improved contact point life and reduced rubbing block wear.
4. Mica-filled molding material which can withstand arc-over with less likelihood of carbon tracking.
5. Cam lubricators that constantly lubricate the cam and rubbing block.
6. Shock-absorbing couplings for reducing torsional vibrations frequently transmitted through drive to governor weights and rotor. This reduces wear.
7. Oil reservoir lubrication with porous bearing material provides ample constant lubrication without requiring frequent attention.
8. Rigid flange mountings offer more positive hold-down and precision alignment.

A program is under way to standardize and simplify distributor designs. New heavy-duty distributor designs have reduced the number of parts and facilitated inspection and servicing. Progress also has been made with electronic ignition systems. A number of them have been operating experimentally with good results. But they probably will not be in production for some time since automotive engines of the near future will not require such expensive, more complicated ignition system.

In the charging equipment department we seem to be chasing an elusive goal. With electrical load requirements for trucks and buses ever increasing, it's anyone's guess where the trend is going. Not too long ago a 50-amp, 12-v generator was considered big stuff for buses; today 160-amp units are in popular use and we're looking for bigger ones.

Improvements making possible higher output ratings without increase in size and weight are:

1. Forced ventilation for commutator and armature cooling.
2. Improved insulation. Included are spun glass wrapping and sleeving, nylon coatings on magnet wire, and better impregnating varnishes to seal windings against moisture and to protect them from vibration damage.
3. Welded commutators to insure low resistance connection at commutator risers.

Study is being focused on generator applications as a whole. Items being taken into account are engine speed range, electrical load characteristics, percentage of time used, and location of generator and regulator with respect to heat and vibration.

Such a study revealed that charging rate at idle speed is a must for city motorcoach generators. A split field generator developed meets this need. Two independent field circuits can be regulated by independent regulators; this greatly increases the strength of the steel for the low speed operation. The present job can put out about 80 amp at engine idle speed, with maximum regulated output of 120 amp. See Fig. 2.

Lots of possibilities are seen for a-c generators in the automotive field. The alternator uses a rectifier instead of a commutator, eliminating the commutator and brushes together with their attendant evils. Things favorable and unfavorable can be said for the alternator. As generator speeds and loads increase, advantages favor the alternator. But the d-c machine has definite economic advantage in the lower capacity class.

Wartime aircraft experience points to improved d-c generator design using six poles with interpoles. This type of field greatly improves commutation and is expected to at least double present brush life. A 160-amp, 12-v machine of this type is being used on interurban buses.

This generator is used with a carbon pile regulator which permits a high field current never before tolerable in vibrating type regulators. This new carbon pile regulator offers many possibilities in bus, marine, and other heavy-duty operations.

Records Key to Maintenance

Despite these advances in electrical equipment design, proper maintenance still is the one way to get best possible service from equipment. Most reliable guide to efficient servicing procedure, particularly, for large fleets, is a service record system.

Especially for batteries is it important to maintain inspection and service records. Periodic report of electrolyte specific gravity and of water required per cell often forewarns of trouble in the battery itself or in other electrical system components. The trouble can be cured before it becomes damaging.

For example, a record showing a progressively lowering specific gravity indicates possible trouble in the generator or regulator. If the trouble is not attended to, it may permanently damage the battery or burn out the cranking motor because of attempts to crank on low voltage.

A battery record that shows overcharging together

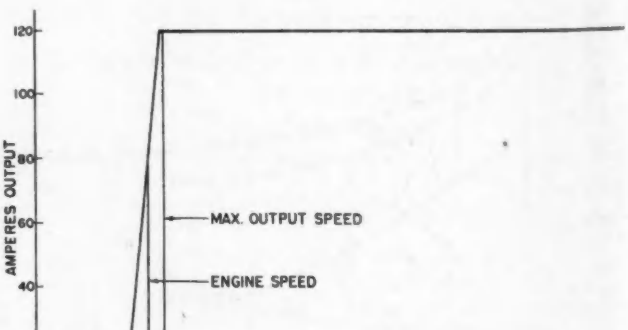


Fig. 2—New generators designed for city bus operation have good charging rate at idle speed. This design, with a 2 to 1 generator ratio, develops 80 amp at engine idle speed and 120 amp as a maximum

with excessive use of water warns of high charging voltage; it calls for immediate corrective measures to prevent high voltage damage to all units in the electrical system. Frequent addition of water to one cell and not the others may indicate a cracked case or an internal short in that cell. In either case, removing the battery from the vehicle will prevent a costly road failure later.

Battery maintenance is gaining the recognition it deserves, particularly from the standpoint of battery water. Too much depends on batteries to allow careless filling of cells from the wash hose. Unless you can find out from a complete analysis what your city tap water contains, it is safer to depend on distilled water. The cost of a battery ruined by mineral contamination will pay for many gallons of distilled water.

Along this same line concerning battery dopes, there is only one point to remember regarding their use—DON'T. Battery manufacturers are doing everything they can to improve battery life. When a dope is developed that turns the trick, they'll get it to you. Dopes analyzed to date are either harmless inert materials, strong detergents that wash away usable materials, or strong acids that burn up remaining usable material in a quick burst of energy.

A suggestion on installations where two or more batteries operate in parallel is to try to use batteries of nearly the same capacity. An old worn battery paralleled with a new one, or a small battery teamed with a large higher capacity one foments trouble. The counter voltage developed by each battery will be different. Since it is counter voltage that determines regulator action, the weaker battery very likely will be continually overcharged.

Battery Affects Cranking Motor

Battery service records also come into play in maintenance of cranking motors. A low battery, which periodic inspection will disclose, causes frequent abuse of the cranking motor. So does a bad connection. Either of these conditions results in low voltage at the motor terminals. This makes the motor crank slowly so that intense local heating builds up at commutator and brushes.

Voltmeter readings at the starter terminals tip off high resistance or low battery. Burning or oxidation of starter switch contacts also may cause low terminal voltage.

Since automotive cranking motors are necessarily overrated, they can be used only for short intervals. Extending cranking cycles over 30 sec invites damage, particularly with larger gas and diesel engines. Only real preventive measure against extended cranking is good maintenance of the engine itself to permit starting with a reasonable amount of cranking. If an engine fails to start after 30 sec of cranking, something needs attention.

Any cranking motor's drive mechanism has a heavy assignment. It must be kept free from dirt that would retard its freedom of action. For the Bendix type drive, most sensitive to gum, periodically flushing drive parts with diesel oil cleans effectively. It carries away gum and packed dirt and keeps the parts lubricated. The same treatment will keep parts of the Dyer type drive clean and working smoothly.

To maintain precise operation for which the ignition system is built, a systematic procedure is important to see that all components are working at their specified ratings. Briefly the step-by-step checkup runs something like this:

1. Test battery and cables to be sure sufficient voltage is available to ignition system.
2. Test coil and condenser.
3. Test distributor. It is advisable to make this test on a synchroscope, where all phases of distributor can be checked quickly and accurately. Items to inspect are contact point condition and alignment, spring tension, point opening or cam angle, vacuum advance action (if any), automatic advance, and synchronism.
4. Inspect cap, rotor, and coil tower for evidence of burning or carbon tracks. Clean these molded parts to prevent any dirt accumulation that would present possible leakage path to ground.
5. Check high tension leads. Brittle or cracked insulation on spark-plug cables may cause missing or hard starting, particularly when damp.
6. Check spark plugs for improper gap, fouling, cracked or leaking insulators. Occasionally unusual service conditions make contact points consistently transfer in one direction, causing pitting. In such situations some compensating changes can balance the capacity for specific requirements.

Where negative point loses material with a build-up on the positive, any of these changes will tend to reduce pitting:

a. Increase condenser capacity.
b. Separate low-tension and high-tension leads between distributor and coil, or locate these leads closer to a good ground.
c. Shorten the condenser lead.

If the material transfers from the positive point and builds up on the negative:

1. Decrease condenser capacity.
2. Put low and high tension leads together by taping or running in common loom.
3. Lengthen condenser lead.

Servicing generators and regulators also hinges on accurate records. Battery records will tell whether the voltage regulator settings you use are right for your operation.

New thinking on voltage regulator settings has it that attention should be focused on the setting to meet specific operation requirements, rather than on arbitrary values set up in test specifications. This amounts to adjusting voltage regulators according to the hydrometer. Though not to be taken too literally because of the many factors to be taken into account on battery readings, the idea is to establish the best setting for the particular service based on battery charging results.

Paramount to long generator life is the wisdom in selecting the right unit for the particular application. For example, a generator designed for an intercity coach would probably fail miserably if the bus is used only in city and suburban operation. And for the same truck model there are available standard-duty, high-speed, low cut-in, and heavy-duty generators so that the user can select the design best suited to his particular needs.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Daily Bird-Plane Collisions

BASED ON PAPER* BY

Pell Kangas and **George L. Pigman**

Aircraft Development Division
Technical Development Service
CIVIL AERONAUTICS ADMINISTRATION

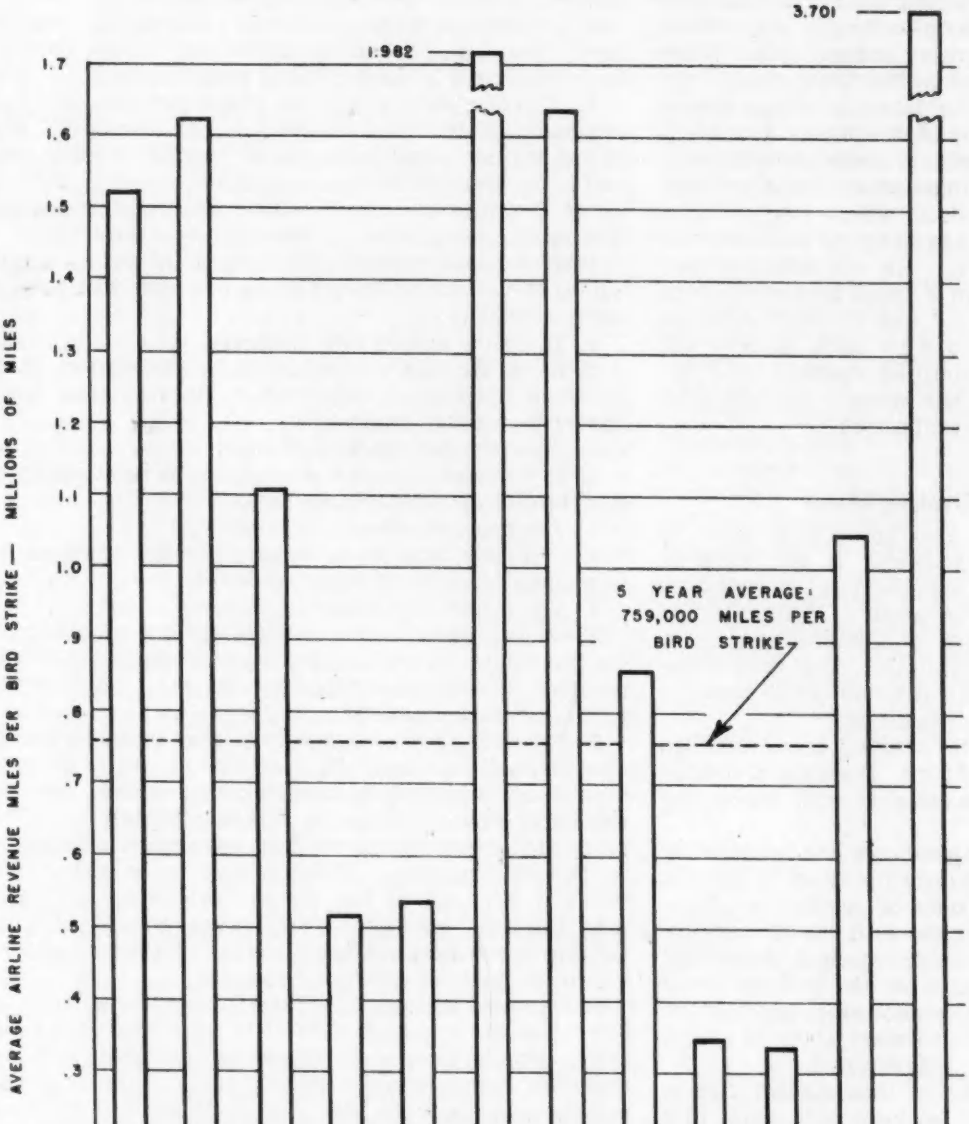


Fig. 1—Monthly frequency of bird collisions with airplanes averaged from data collected over a five-year period

Show Windshield Weaknesses

FLYING birds collide with airplanes in this country oftener than once a day, according to a five-year Civil Aeronautics Administration survey. One of every four bird "attackers" strikes the windshield, with sometimes disastrous and occasionally serious results. Simulating this ethereal conflict in the laboratory, by catapulting bird carcasses against windshields at the equivalent of 450-mph flying speeds, discloses ways to make windshields more bird-impact resistant.

The 1942-1946 CAA survey points up for the first time facts about bird-aircraft collision. With its rate of occurrence on the upgrade, this type of accident damages the airplane, may injure the pilot, and threatens even greater hazards with the advent of larger, faster commercial aircraft. Highlights of the pattern woven by this accident study are the frequency of collision, season of year, altitude of bird hits, type of bird, geographical distribution of bird hits, distribution of hits and the airplane itself and their severity.

Bird collision statistics were interpolated to find the average number of revenue miles flown for each bird strike. It was done because reports on bird collisions are incomplete; airline operators tend to neglect those strikes that do not damage the airplane. For this reason the data from one airline, which is known to be reasonably complete, has been taken as a good statistical sample. This airline flies about 20% of total revenue miles in this country. Using these data as a base, the bird collision frequency was plotted in Fig. 1.

Fig. 1 shows that the bird strike occurs every 759,000 miles of scheduled air carrier operations. Since 309,592,647 miles were flown on all scheduled flights in 1946, 759,000 miles covers about 0.89 days. Thus the 1946 bird flew into its man-made counter-

*Paper "Development of Aircraft Windshields To Resist Impact with Birds in Flight," was presented at SAE National Air Transport Engineering Meeting, Kansas City, Dec. 3, 1948. . . . Complete paper on which this article is based is **not** available, but the material on which the paper was based appears in Technical Reports No. 62 and 74, published by the Civil Aeronautics Administration.

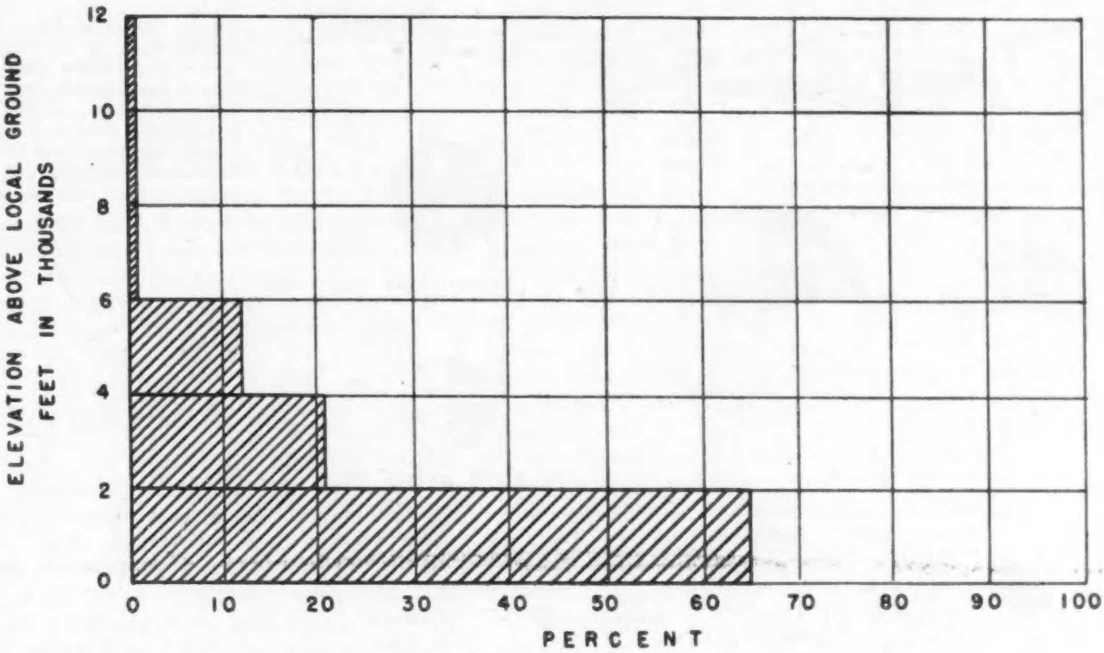


Fig. 2—How frequency of bird collisions varies with elevation above local ground. Less than 5% of these collisions occur at altitudes greater than 6000 ft above local ground

part about eight times a week, or 408 times during the year on all airlines.

With 440 million revenue miles anticipated in 1950, bird will meet airplane about 12 times per week. And higher cruising speeds will bring more severe damage from such collisions.

Another significant item in Fig. 1 is the large variation in collision frequency with season. Collisions occur most often when migration is at a maximum. Birds strike airplanes about ten times more often in September and October than they do in December. The strike frequency during these months is double the annual average frequency.

Accidents Versus Altitude

Fig. 2 shows the altitude above local ground level at which bird collisions occurred. The figures are based on 107 reports. Note that about two-thirds of all collisions took place at less than 2000 ft above local ground elevation; 95% happened at less than 6000 ft. But operators report bird strikes at altitudes of 12,000 ft. And collision at all higher altitudes involve greater flight speeds and possibly greater potential hazard than the 0-2000 ft level.

Most of the bird strikes involved ducks, gulls, and buzzards, with only a small number of 16 other types. Ducks weighing from 1 to 5½ lb are most commonly hit. They are encountered in all parts of the country at all normal flight altitudes, especially at night. Ducks colliding with the airplane windshield usually cause severe damage.

Gulls are hit most often at low altitude and during daylight hours. Impact of gulls on the windshield also usually damage the windshield severely. Buzzard hits are recorded at altitudes below 4000 ft, and almost always in daylight. Although there are only two recorded cases of buzzards hitting windshields, they severely damage wing and nacelle structures.

Geographical distribution of bird strikes correlates reasonably well with distribution of bird migration density, except for a small number of strikes found in the northwest border states and Mississippi River area. The migration pattern shows the greatest concentration of moving migratory birds may

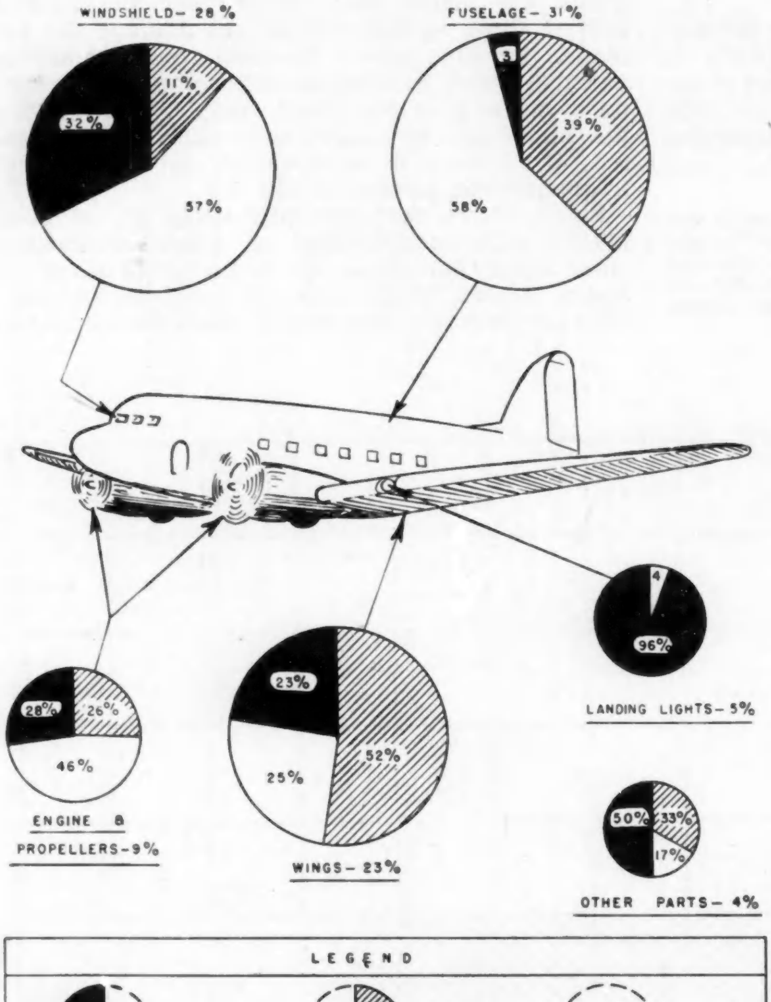
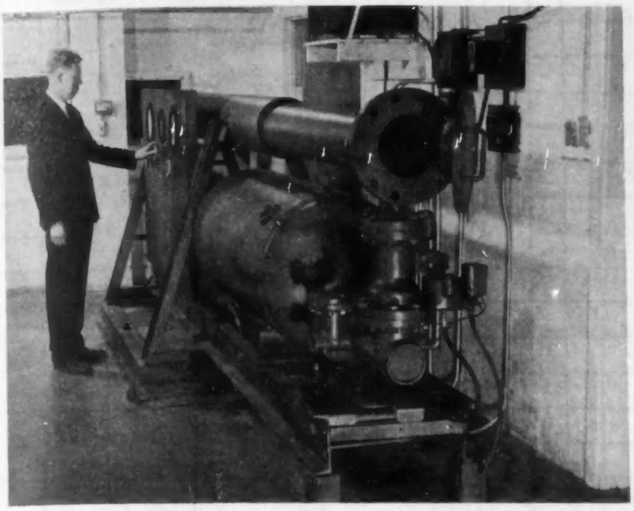
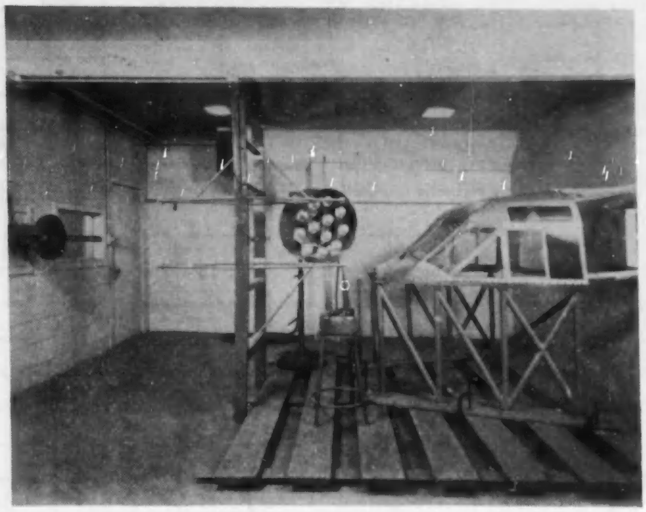


Fig. 3—This shows how often birds strike various parts of the airplane and how severe the damage is. Severe damage consists of considerable buckling or indentation, penetration, failure of any part of the metallic structure, damage affecting engine operating conditions, or major cracking or penetration of glass. Moderate damage includes minor indentation of metal or minor cracking of glass

Test Methods and Equipment





From the hunter's standpoint, laboratory impact testing of aircraft windshields assumes a man-bites-dog status. Bird carcasses are shot from a gun at the windshield panel.

The gun is shown above. Gun barrels with 3 to 8-in. inside diameters were used, capable of projecting birds weighing from 1 to 16 lb at any predetermined speed up to a maximum of about 450 mph.

Chickens and turkeys used in the tests were electrocuted just prior to the test and fitted into a light cloth bag for insertion into the gun. (Electrocution retains characteristics as close as possible to living conditions.) Bird carcasses were used because they provide reproducible test results and because it's hard to find a substitute projectile with the elastic characteristics of a real carcass in high-speed impact.

After leaving the gun muzzle, the carcass breaks a set of fine steel wires placed across its path for speed-measuring purposes. Two wires of the set are spaced 5 ft apart and are connected to a galvanometer oscillograph which indicates corresponding time interval. Two other wires in the set are connected to a direct-reading chronoscope. This gives two independent speed measurements.

Gun air-tank pressure gives desired carcass velocity within 10% accuracy.

Windshield panels are mounted in various types of supporting structures. In most tests—mainly for determining only panel strength and panel impact characteristics under various conditions—a standard steel frame was used. Some tests were made with a portion of the airplane cockpit structure for mounting the test windshield panels. Shown above is a typical cockpit structure setup for impact testing. The structure is rigidly clamped to the test chamber floor and supported against the rigid rear wall by wooden braces behind each of the main longitudinal structural members.

Panel temperature at time of test was measured with thermocouples contacting each face of the panel. High-speed motion pictures helped in understanding the nature of impact and mechanism of failures. Optical deviation tests of windshield panels were made by photographing a grid through the panel.

be expected in these regions: the Great Lakes area, along the Mississippi and Missouri Rivers, across the northern states from Minnesota to Montana, and in the interior valleys of Oregon and California.

Greatest number of reported bird strikes occur along the eastern coast from Washington, D. C. to Boston; in a north-central band from Ohio through Iowa and Missouri; in the general Colorado and Utah area; and in western portions of California, Oregon, and Washington. A general scattering is found throughout the southern states, with some concentration around principal air traffic centers. Few strikes were reported in the northwest border states.

Where Birds Strike Planes

Crux of the survey is the group of data telling where the birds struck the airplanes and the kind of damage inflicted. The story in a nutshell is told by Fig. 3. It shows the percentage of all strikes on windshield, wing, fuselage, engine and propeller, landing lights, and miscellaneous parts such as antenna masts, icing indicators, and tail structure.

Most striking feature in Fig. 3 is that the windshield received 28% of all recorded strikes, although it represents much less than 28% of the airplane's total forward area. By the same token, the relatively small landing lights absorbed 18% of the hits on the wing and 5% of those on the entire airplane.

Explanation for these data is that the windshield and landing lights are more readily damaged by collisions with birds than are metallic parts of the structure. Bird strikes on the windshield are seen directly and commonly reported, even though no damage is done.

About 43% of the 137 windshield strikes reported caused some damage; 32% caused severe cracking or penetration. In 10% of the strikes the bird penetrated the windshield and entered the cockpit along with glass particles. In five of these cases the cockpit personnel were cut by flying glass and in a few, struck by the bird. Cockpit personnel required hospitalization in many instances where severe windshield damage was involved.

No fatal injury is attributed to bird strikes in commercial airline operations. But in several unexplained fatal crashes of commercial transports bird collision was suspected. The military services carry numerous cases on their aircraft operation records of fatalities and aircraft crashes from bird collision.

Bird impact on the engine and propeller package

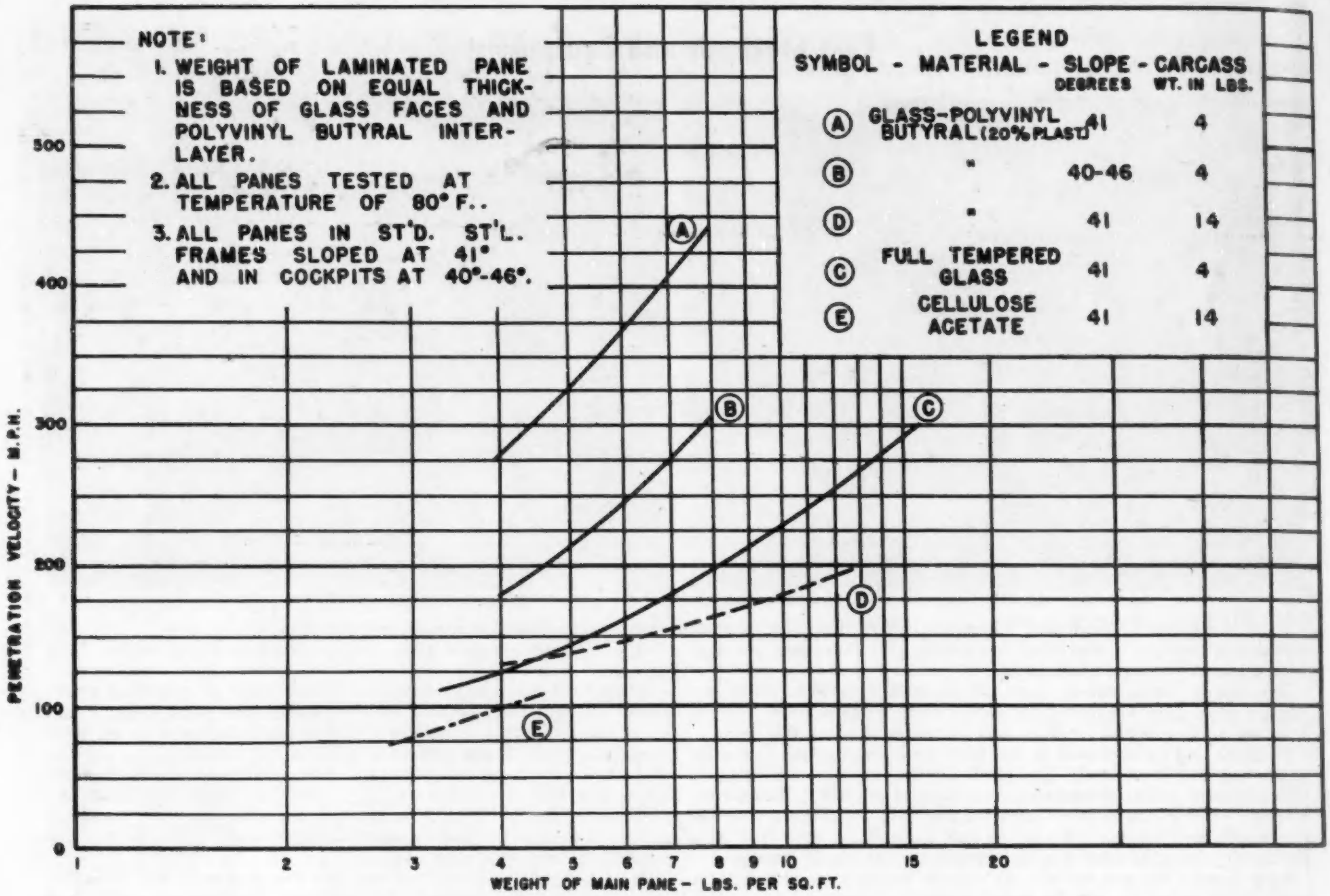


Fig. 4—For the same resistance to impact, a laminated glass-plastic pane weighs much less than a full-tempered glass plate. These test curves show the glass plate weighs about 2.6 times the laminated one to develop the same impact resistance against a 4-lb bird striking at a speed of 300 mph

resulted in severe damage in 28% of the strikes recorded for this location and in moderate damage for 26%. Normally, damage sustained by the powerplant wasn't sufficient to cause shutdown. But in three instances a bird jammed the airscoop for the carburetor. In one such case an engine failed on take-off; in another, the engine could not be idled.

Birds striking the nacelle have broken rocker arm housings, torn ignition harness, loosened cowling in more severe cases, made dents in the cowling and lodged between cylinders or in air intake ducts in less serious cases. Miscellaneous parts of the airplane received 4% of the strikes, half of which caused serious damage. The tail structure has been hit relatively few times. But one such strike by a large bird caused considerable damage to the vertical stabilizer and partial loss of rudder control.

Because bird collisions with the windshield can lead to the most serious consequences, tests were made to investigate impact-resistance of windshield materials and mounting methods.

Tests showed one type of windshield pane superior to all others from the standpoint of impact strength-weight relationship. It's the type with glass faces and a thick polyvinol butyral plastic interlayer, which extends beyond the glass edges on all sides for bolting to the mounting frame.

Fig. 4 compares penetration velocities measured with various weights of plastic laminated panes with those of various weights of full-tempered glass plates. It shows that for a penetration speed of 300 mph, a full-tempered glass plate weighing 260% more than the extended plastic edge type is needed to get the same impact resistance against a 4-lb bird carcass.

The laminated plastic construction has such high impact resistance because it can deform so much under large loading forces without failing. The butyral plastic bolted to the frame around its edge forms a flexible membrane after failure of the glass faces, with high tensile strength and elongation. Such a plastic sheet absorbs considerable energy before failure.

Effect of Thickness

Resistance of a windshield panel to bird impact, as measured by carcass speed required to penetrate, varies approximately as the logarithm of pane thickness. In the laminated glass-plastic type with extended plastic edge, thickness of glass has little effect on impact strength. Thickness of butyral plastic interlayer primarily determines impact strength of this type pane.

In a double-pane arrangement—with relatively

thin front glass having good thermal transmission characteristics—the front pane contributes little to impact strength of the combination.

Angle of impact on the windshield panel greatly affects its impact strength. According to test data, impact strength (measured by carcass speed required for penetration) varies approximately as the secant of total angle of panel slope.

Size and shape of windshield panel, over a considerable range commonly used in aircraft, affect impact strength but slightly. It was found that varying the flat-panel shape from a 1-ft × 1-ft square to a 1-ft × 3-ft rectangle doesn't appreciably change the penetration speed for impact normal to, and at the center of, the panel. The same is true for changing the area of square panels by a factor of four.

Bigger Windshields Better

However, a 2-ft × 2-ft panel had a 40% greater impact strength than smaller panels when tested at a slope of 41 deg. Highly sloped, curved, laminated panes were attached to a cockpit structure by the clamped-edge type mounting. These panes also had unusually high strength, corroborating the 2-ft × 2-ft panel tests, despite the clamped-edge mounting. This may be due partially to the large slope angle—63 deg; but undoubtedly high strength also is associated with large panel size. This panel fails locally, except where impact is close to one edge. Tensile forces developed in the plastic interlayer were so small for each unit length of large edge dimensions that the panel did not pull from the frame, as smaller panels of this type ordinarily do.

Fig. 5 shows a high-speed motion picture study of impact near the forward edge of such windshield. It illustrates the failure of the clamped edge mounting. Here the carcass is deflected upward because of the unusually steep slope of the windshield. Formation of a cloud of glass splinters also is evident as an impact reaction. The inner face also splinters into the cockpit.

Although superior to other types, the combination glass-plastic windshield with extended plastic edges bolted to the cockpit frame do fail. These are the common types of failures:

1. Shearing of extended plastic edge at bolts,
2. Shearing of pane at inner edge of metal strip inserted in the extended plastic edge,
3. Failure in main body of pane, usually in form of tear in plastic interlayer,
4. Failure or severe bending of windshield frame,
5. Shear or tension failure of panel mounting bolts,
6. Failure in hinge, clamp, or bolt attachment of the windshield frame to the sills and posts.
7. Failures of sills or posts, or their attachments to the aircraft structure.

Optical properties of laminated glass-plastic panes vary with ratio of glass-to-plastic thickness. Tests show that thickness of each glass face should equal that of the plastic interlayer to get normally acceptable optical characteristics.

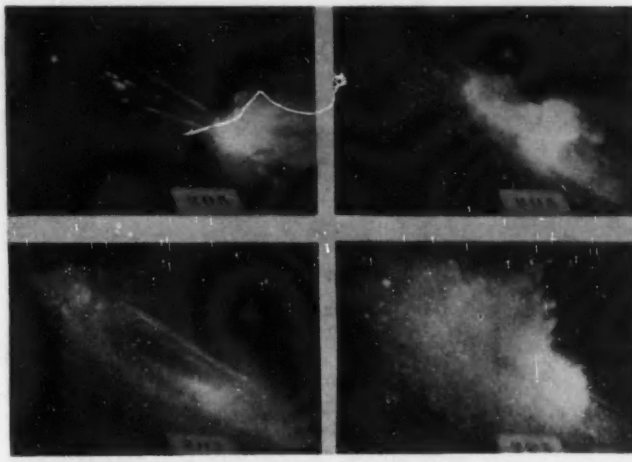


Fig. 5—These high-speed motion picture stills show the failure of the clamped edge mounting. The impact threw up a shower of splinters on the inside as well as the outside of the windshield. Time sequences measured from the first frame are 0.004, 0.013, and 0.082 sec

Added to the hazard of a bird penetrating the windshield and entering the cockpit with substantial residual velocity, is that of sharp-edged glass and plastic splinters. Fig. 6 shows glass splinters thrown off the rear surface of a laminated pane during impact. Impact, with or without penetration, produces broken particles with all types of glass used for the pane rear surface.

Tempered or annealed glass yields large quantities of high-speed splinters. Methyl methacrylate plastic and other similar hard plastics on the pane rear face greatly reduce splintering; but they produce undesirable optical characteristics. Suspending a thin sheet of hard plastic behind the standard glass-plastic laminated pane stops splinters. But it generally is broken by the large distortion of the plastic interlayer and also has undesirable optical characteristics.

Another piece of information disclosed by impact tests is that panel mounting bolts should be spaced at least two bolt diameters from the edge of the panel. In general small bolts at close spacing provide more uniform support than large bolts at wide spacing.

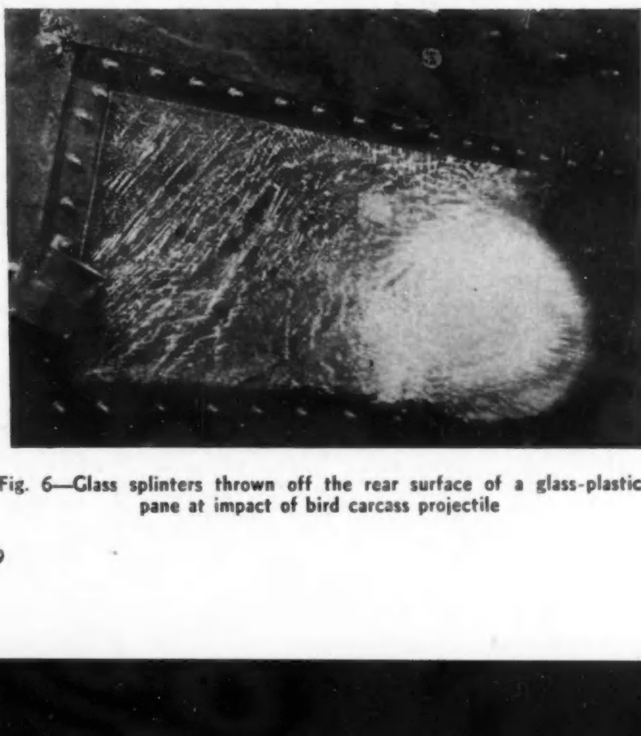


Fig. 6—Glass splinters thrown off the rear surface of a glass-plastic pane at impact of bird carcass projectile

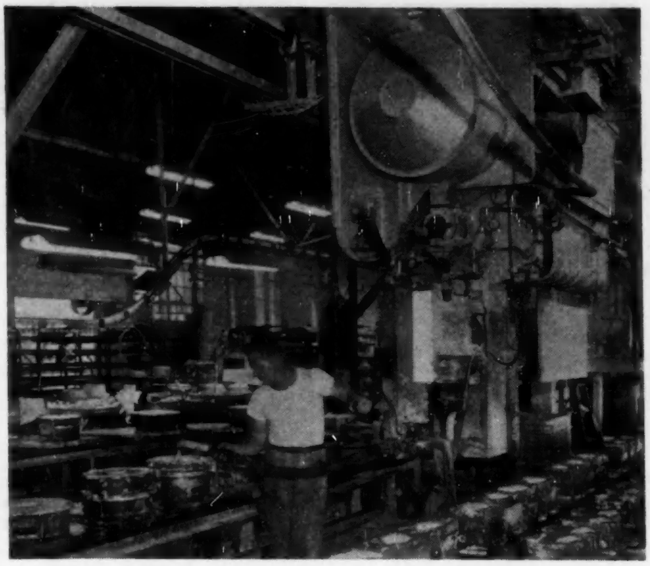


Fig. 1—Pouring the plaster molds by use of a hose through which slurry is pumped from the mixing machine

Fig. 2—Box form, into which the plaster slurry has been pumped, is being removed from the drag mold

Aluminum Cast

BASED ON PAPER* BY

E. A. Canning

Director, Sales & Engineering,
Allison-Bedford Foundry
Allison Division, General Motors Corp.

FIRST aluminum castings to satisfy the Allison aircraft engine endurance tests, and elements of the Buick Dynaflow transmission are cast by a new plaster mold process based on pioneering work of a couple instructing sculpture casting at Antioch College, Yellow Springs, Ohio.

At the present stage of development, the process is limited in economy, and should be used only in producing parts of complicated design which cannot be made more economically by other methods.

The process does not use wax and plaster, as does the procedure developed by Mr. and Mrs. Morris Bean at Antioch, but was developed entirely through their efforts.

Basic ingredient of the mold material is gypsum or calcium sulphate. Mines in Michigan produce high purity materials. Dry mixed with the gypsum in closely controlled proportions are sand, asbestos, talc, and sodium silicate.

Water is added in controlled proportions, and the resulting mix or slurry is pumped into drag molds, Fig. 1, to form molds into which molten metal is poured. Proper amount of the slurry is controlled by the operator.

Cores Set Rapidly

The slurry looks like ordinary gray plaster, but hardens or sets sufficiently to handle in from five to 10 minutes.

In this condition the box form is removed from the plaster drag mold, Fig. 2, and the form is removed from the plaster core mold, Fig. 3.

Elements of plaster molds and cores are then assembled into complete molds, Fig. 4, and are ready for the curing process. The assembly, now an envelope to receive the melted metal, is set in its green condition for six hours.

They are put into autoclaves and steamed under 17.5 psi for about six hours. They are then air cured for 12 hours, and finally oven dried at 450 F from 12 to 20 hours, depending upon the size of the mold assembly. The assembly for the Dynaflow trans-

*Paper "Relation of the Antioch Process to the Foundry," was presented at SAE National Production Meeting & Clinic, Cleveland, Oct. 21, 1948.

Fig. 3—Here the box form is being removed from the plaster core mold preparatory to assembly with other cores

Fig. 4—Assembling the complete mold which, after proper curing and drying, will receive molten metal

In Plaster

mission torque converter casting requires a cycle of 40 hours before the molds or envelopes are ready to receive the melted metal.

During the curing period much of the water added to form the wet mix has been driven off. Evaporation is limited to reconvert the gypsum to a hemihydrate condition, and the autoclave treatment changes the internal crystalline structure, which gives the assembly considerable permeability and a reduced dry strength. Permeability is essential to permit entrapped air and gas to escape during pouring and metal solidification. This change in crystalline structure is a unique feature of the Antioch method.

Plaster Makes Better Molds

Complicated shapes are more easily and accurately made with plaster than sand, and the plaster can be made to vary in thermal capacity from an excellent insulator to a mild chill. Aluminum prefers a plaster envelope to sand, and when poured in plaster molds will assume much thinner sound sections than it would in sand. Surface finish of the cast part is far superior when molded in plaster.

Molds are loaded on raised rail conveyor cars and poured at cupola stations, Fig. 5.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

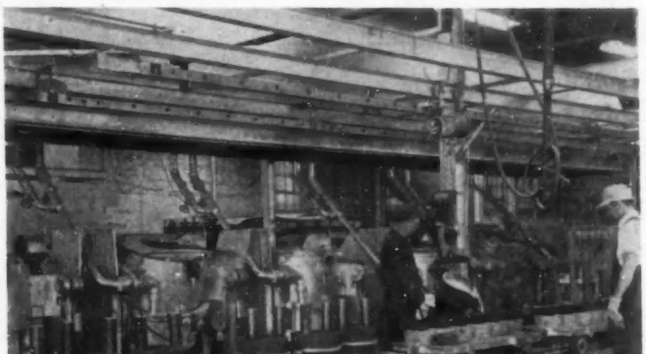


Fig. 5—Narrow gage railroad cars carry completed and cured molds past the furnaces where molds are poured

How Powerplant Installation Hampered Airline Operations

AN 11-YEAR survey from 1937 to 1947 shows fuel and lubrication system failures to be the worst offenders in causing flight plan deviation in scheduled air carrier operations.

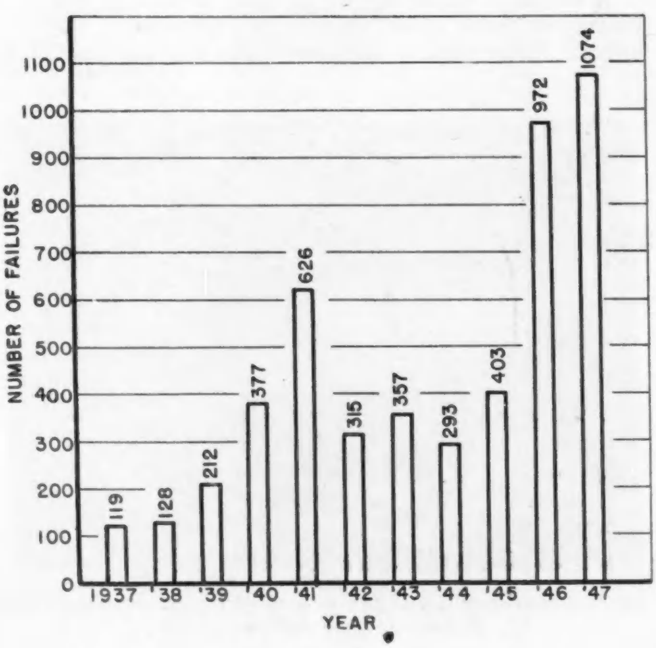
The survey covers mechanical failures, defects, or malfunctions occurring or found during block-to-block time. Not included are the defects and routine inspections and overhauls in the shop.

Thus the figures reflect causes of valuable flight time lost, revenue dissipated, and increased maintenance costs incurred by deviations from the scheduled flight plan. These deviations took the form of flight delays, unscheduled landings, return to the field after take-off to diagnose and correct the trouble, and reductions in power and airspeed.

Such incidents may curtail potential revenue by the possible disturbing effect on passengers.

These troubles have been analyzed as a percentage of both total aircraft and total revenue miles flown to detect any trends. The data also have been broken down into groupings of the engine installation.

Total Engine Installation Failures



This chart of powerplant installation failures during the 11-year period indicates that these difficulties increased about 500%, and fairly rapidly, from 1937 to 1941; remained fairly stable during the war years; then jumped to three times that average level during 1946 and 1947.

Overall total increase from 1937 to 1947 was about 900%, which represents a 25% yearly increase. To make a rational comparison of these values, two main operating factors, and possibly a third must be taken into account: (1) number of aircraft, (2) number of aircraft revenue hours, and (3) airplane speed.

Also to be remembered is that most engine installation components—lubrication, exhaust, cooling, and induction systems—are proportionate to the number of engines in the airplane. A four-engine aircraft will have twice as many as a twin-engine machine.

For this reason it is important to be cognizant of the relative number of two, three, and four-engine aircraft in any one year when considering the number of troubles due to a particular component. This factor is not reflected in the breakdown of troubles by components in this study.

Troubles —1937-47

BASED ON PAPER* BY

JOHN W. BAIRD

Assistant Chief Engineer
Powerplant Engineering Division
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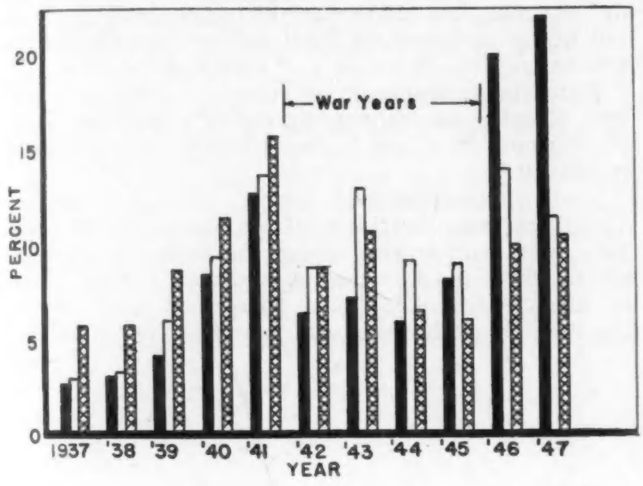
Troubles Prorated



This chart intends to weigh the importance of both number of aircraft and aircraft revenue hours as to their influence on number of troubles reported.

Number of failures reported each year is indicated by the solid black bars; number of troubles per 100 aircraft is indicated by the light bars; number per 10,000 aircraft revenue hours is shown by the hatched bars. All are shown as a percentage of the total for the 11-year period.

The black bars reflect directly the values in the chart on the previous page. Fact that the black bars are more nearly proportionate to the light ones than to the hatched ones indicates this: Number of aircraft more accurately reflects the number of troubles reported than the basis of aircraft revenue hours.

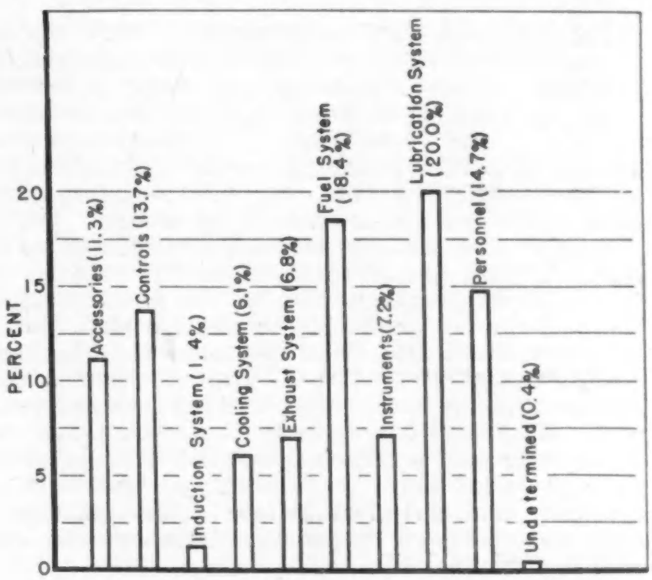
If the number of troubles represented by the black bars were reduced in proportion to the number of aircraft for the corresponding years, values of black bars for 1946 and 1947 would be 18.5% and 18%, respectively.

Breakdown of Engine Installation Troubles

This chart breaks down the powerplant installation troubles into their main divisions or classifications. Troubles in each classification are shown as a percentage of the total number of troubles reported during the 11-year period.

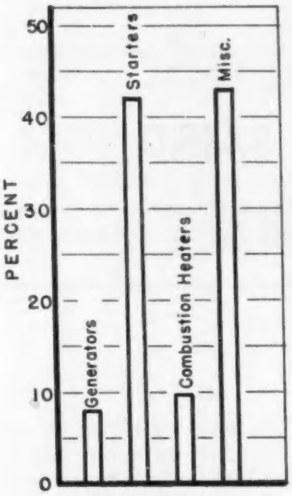
Note that the lubrication system is the worst offender with 20% and the fuel system second with 18%. Personnel, surprisingly, is a close third at around 15%. Controls are next at around 14%, followed by accessories, 11%; instruments, 7%; exhaust system, 7%; cooling system 6%; and induction system, the mildest offender, about 1%.

A detailed study of the elements in each classification is presented on the following pages together with an analysis of fire occurrence stemming from the powerplant installation, both on the ground and in the air. The trends indicated may hold significance for current and future operations and design.

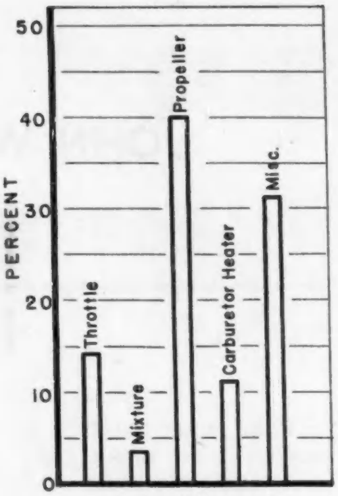


* Paper "Survey of Powerplant Installation Troubles in Scheduled Air Carrier Operations," was presented at SAE National Aeronautic and Air Transport Meeting, New York, April 13, 1948.

Accessories and Controls



ACCESSORIES
(11.3%) of total)



CONTROLS
(13.7% of total)

In the accessory category, generator troubles form no definite trend. Most failures or defects can be ascribed to electrical faults—such as excessive brush wear, shorted terminal wires, dirty voltage regulator points, oil or dirt on the commutator, or field coil wires broken by vibration.

Starters, most prolific source of accessory troubles, suffer electrical afflictions, much like the generator. Mechanical defects include cracked housings, sheared starter dogs, bearing failures, and worn or broken gears. Starter troubles appear to be diminishing.

Combustion heater troubles are confined to 1946 and 1947, when such equipment came into general use. Typical are fouled spark plugs, loose electrical connections, overheating, and leaks. Evidently ample access for inspection should be provided.

Cabin supercharger drive system troubles accounted for about 50% of the miscellaneous group in 1947. High rotating speeds of cabin supercharger drive shafts and relatively large power they must transmit together with design considerations pose new problems for the designer and operator. To eliminate fire hazard, there is need for protecting adjacent structure from damage in event of failure of the high speed revolving shaft—particularly lines carrying flammable fluids.

Propeller control troubles reported over the last four years show a decidely rising trend. The largest contributor to control troubles, propeller control defects manifested themselves in the form of governor pulley and control shaft failures, broken cables, feathering line failures, and electrical shorts.

Throttle control troubles stemmed from loose pulleys, slipping cables, rigging out of adjustment, stiff or jammed throttles, broken linkage, and push-pull rod failures.

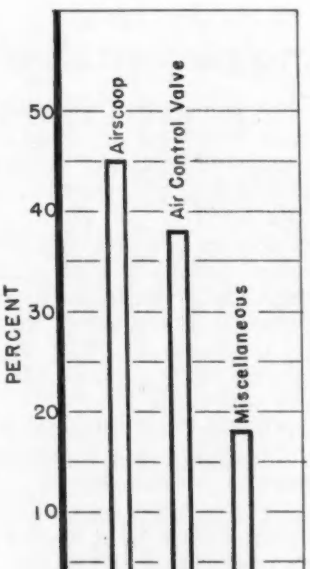
In the miscellaneous group, cowl flap controls and oil radiator shutter controls accounted for about 15% each, and engine blower actuator troubles for about 20%. Engine blower actuator troubles were all experienced in 1947 and comprised about 40% of the total miscellaneous group troubles for that year.

Induction and Cooling Systems

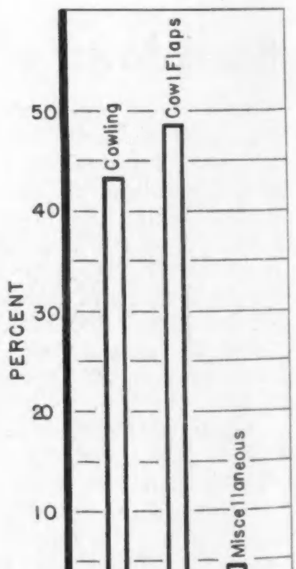
Induction systems contributed a very minor proportion of the total powerplant installation troubles. Airscoop problems are traced to cracks from vibration or backfire pressures and to loose fasteners. Air valve control malfunctions arose mainly from valve jamming or valve failure due to backfires. They should be considered in conjunction with carburetor heater control difficulties.

Typical miscellaneous troubles were due to such isolated items as carbon paper on the carburetor intake screen, paper napkin in the airscoop, and remains of a bird on the carburetor air filter.

Cowling difficulties, about 43% of the total for the cooling system, generally were due to loose or failed fasteners, loss of safety clips, buckled cowl formers, and loss of rigidity, cracks in the cowling due to vibration or fatigue. Typical cowl flap troubles were loose or failed flaps, worn bushings, broken flap brackets, and out-of-adjustment limit switches. Limit switches were responsible for about 10% of cowl flap troubles.



INDUCTION SYSTEM
(1.4% of total)



COOLING SYSTEM
(6.1% of total)

Exhaust System and Instruments

Cabin heater troubles in the exhaust system chart relate to heating systems deriving heat from the exhaust, which confines them to older type aircraft. They included freezing, hose and line failures, and cracked or leaking boiler seams. Carburetor heaters suffered mainly cracked, broken, or burned intensifier tubes.

As was expected, by far the largest proportion of exhaust system failures were due to exhaust manifolds and stacks. These accounted for 68% of the total. It is significant that despite all development devoted to design of exhaust manifolds, the number of troubles from this source in each of the last two years equals about three times the average number for the preceding years covered by the survey.

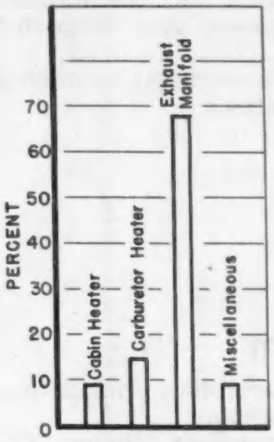
Evidently the number of such troubles per aircraft is not diminishing. Combined effects of high temperature, vibration, and engine movement on these components continue to plague the designer. They loosen clamps, split or burn collector rings, break stacks or flanges, break bolts, and loosen gaskets.

The instrument group incapacitates the powerplant installation to about the same extent as the exhaust system.

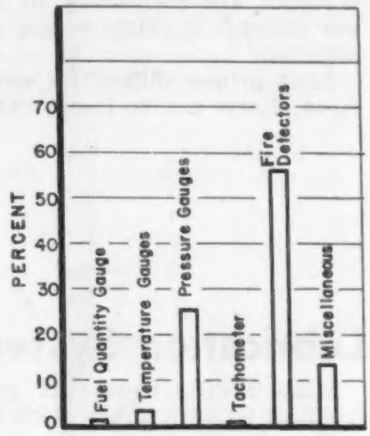
Although negligible, fuel gage troubles are not confined to older type airplanes; they have shown up in latest type aircraft equipped with new type gages. Pressure gage difficulties were largely confined to the last three years. Their number in 1947 were below that for 1946 and they seem to be decreasing.

Troubles from recently-adopted fire detectors first put in their appearance in 1946. They almost doubled the next year and their total for 1946 and 1947 accounted for 56% of all instrument malfunctions for the 11-year period. So many false warning indications were given that some flying personnel were inclined to lose faith in this equipment.

While many of the troubles were due to the fire detector units themselves, most of them resulted from insufficient knowledge or realization of the importance of following proper practices in installing these units.



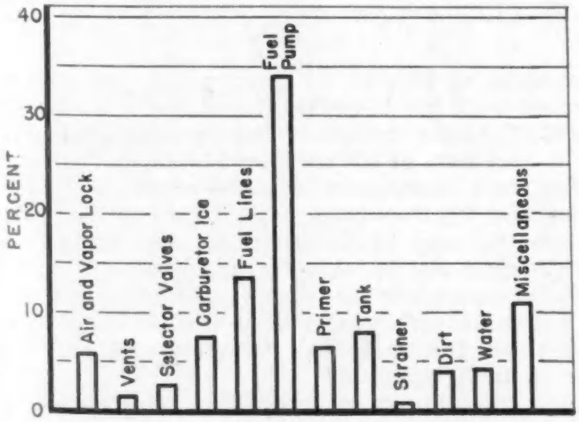
EXHAUST SYSTEM
(6.8% of total)



INSTRUMENTS
(7.2% of total)

Fuel System

The number of fuel system troubles has increased significantly, but the number per aircraft seems to be decreasing. However, no definite trend is indicated.



FUEL SYSTEM
(18.4% of total)

Air and vapor lock difficulties generally were evidenced by engine surging, loss of rpm, low fuel flow or bmep drop, and high head temperatures.

Carburetor icing troubles were relatively few. Apparently fuller realization by designers of induction system icing hazards and indoctrination of operating personnel in proper operating techniques have borne fruit.

Vent troubles included blocked or clogged vents, loose and leaking vents, and fuel escaping from vents. Selector valves, also a minor offender, suffered from leaks, binding shafts, sheared pins, and valve detents failing to position properly.

Fuel lines accounted for about 14% of the total troubles; but based on the number of aircraft operated, the tendency definitely is downward. Undoubtedly increasing use of flexible hose assemblies is beginning to reap benefits. Generally these troubles came from line breakage, leaks, cracked flares at the nut end, and chafing from vibration.

Since the fuel pump is the heart of the system and easily the hardest worked component, the 34% of fuel system troubles attributed to it is not unexpected. Fuel pumps ailed from sheared shafts,

diaphragm ruptures, shafts frozen in bushings, wear, excessive clearance, and gasket leaks. These troubles are increasing in total, but the number per aircraft is fairly evenly spread over the period covered.

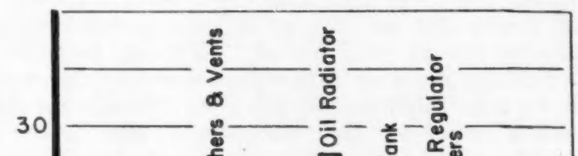
Most primer difficulties were electrical, stemming from shorts due to loose terminals.

About one-third the tank troubles were due to tank cap and gasket failures. Others included external leaks in riveted joints and seams, cracked stress plates, faulty sealing compound, and leaks at mounting pads and the filler neck. Dirt was traced to improper maintenance and inspection of refueling equipment at foreign stations.

Lubrication System

Most prolific source of powerplant installation troubles was the lubrication system.

The oil radiator was the largest contributor. Oil radiator troubles show an increasing trend in both total number and in number per aircraft. Typical of them were oil leaks, cracks in soldered joints, defective cores, and clogging from sludge or carbon deposits. Vibration and congealed oil seem to have been responsible for most.



LUBRICATION SYSTEM
(20.0% of total)

Second big offender, the oil tank, accounted for 25% of total lubrication system troubles. But 80% of this figure sprung from tank caps—defective or damaged caps or gaskets, weak spring clips, loose spring bolts, and worn gaskets.

To alleviate this condition, one operator makes these recommendations to designers:

1. Make it impossible to install the cap with the chain under the seal.
2. Seal the bolt holes in the cap.
3. Use a softer, thicker, and more durable seal.
4. Use a seal retainer to permit turning the cap without breaking the seal.

Troubles from the oil temperature regulator and the oil radiator shutter show an increasing trend both in total number and in total per aircraft. Here are some typical defects: sticky regulator contaminated from carbon, warped bimetallic valve, bimetallic spring frozen in unit, sludge in regulator, regulator sticking in closed position, sylphon broken or elongated, and radiator shutter binding or sticking in the open or closed position.

Foaming troubles usually were attributed to either water in the system or a too-high oil level in the tank. They generally were reported as engine throwing oil or oil foaming from the tank cap. On return to the field, the usual remedy was to lower the oil level or to vent the tank, allowing the foam to settle, and then proceed.

Personnel

Personnel errors fall into three main groups—those connected with the fuel system, the lubrication system, and those connected with all other powerplant installation components. (This is shown by the chart on top of the next page.) General nature of these errors was improper installation of a component, failure to fasten attachments or failure to fasten them securely, and omitting to safety-wire connections to prevent them from working loose under vibration.

Lubrication system errors were most numerous, 63% of the total being in this category. Those associated with the fuel system amounted to 20% of the total, or 80% of all personnel errors were concerned with the lubrication and fuel systems. And most of these consisted of improperly installed caps.

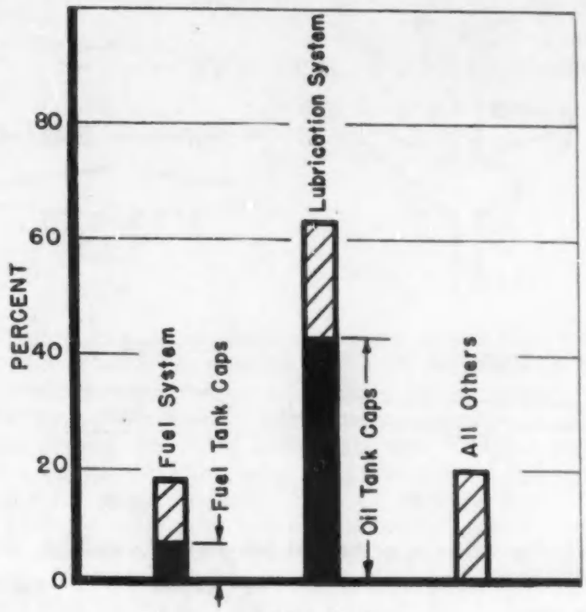
In fact half of all troubles classified "personnel" stem from improperly installed caps—43% oil tank caps and 7% fuel tank caps. This fact should be taken to heart by designers as well as operators. Obviously there is room for improvement in design of tank caps when they permit such large percentage of personnel errors attributed to their installation—one-third the fuel tank troubles and one-fourth the oil tank troubles.

Aim should be to incorporate in these caps a locking and sealing arrangement that will be both positive and foolproof. The design should be sufficiently

sturdy to withstand the handling these components receive. Adequate indoctrination of maintenance personnel on importance of properly securing tank caps and careful inspection before airplane departure will go a long way toward helping reduce these errors.

Personnel errors show a rising trend in total, but a decreasing trend when compared with the number of aircraft. Analysis on the basis of errors per 100 aircraft by years show this to be so. Data were collected to determine whether dislocation of personnel and large assimilation of new workers by airline operators during the war years had any influence on the number of personnel errors.

Personnel errors did increase markedly during the war. But to ascribe this solely to influx of new personnel is hardly warranted. Other factors should be considered when interpreting these results. For example, unavailability of replacement parts during that period probably exerted some influence.



PERSONNEL
(14.7% of total)

Classification	Component or Cause Responsible	Number of Fires on Ground	Number of Fires in Air
Accessories	Starter failure caused electrical fire	1	
	Combustion Heater	4	2
	Cabin Supercharger drive shaft		4
Controls	Cowl Flap Lines	3	
Induction System	Airscoop (backfires)	11	
Exhaust System	Oil in manifold	3	
	Torching	5	
	Collector ring leak	1	
	Manifold broken		2
	Manifold bracket failure		1
	Carburetor air heater		2
Fuel System	Fuel line failure	7	3
	Primer line failure	2	
	Vapor vent return line failure	4	
	Strainer gasket leak	1	
	Primer leak		1
Lubrication System	Oil dilution solenoid	1	
	Backfire ignited oil leak		1
	Foaming oil ignited		2
Personnel	Overpriming	6	
	Pressure line disconnected	2	
	Strainer gasket improperly installed	1	
	Oil dilution line disconnected	1	
Undetermined		2	5

Fires

During the 11-year period covered by this survey, 78 fires attributable to powerplant installation were reported—55 on the ground, 23 in flight. The table at left classifies the fires as to source.

Since consequences of a fire, once started, are usually unpredictable, no consideration is given to magnitude of fires reported. Occurrence of fire is considered of greater magnitude when comparing components with respect to freedom from fire hazard.

According to these records, worst offenders with regard to fire hazard were: fuel system, 23%; exhaust system, 18%; accessories, 14%; induction system, 14%; and personnel, 13%. Note that combustion heaters and cabin supercharger drive shafts were responsible for practically all fires assigned to the accessories classification.

It is surprising to find such small number of fires traced to the lubrication system and the relatively large number attributed to personnel errors. Of the latter, overpriming was easily the most prominent factor; it should be considered in conjunction with fires due to backfire and torching, which together accounted for about 30% of the ground fires.

It would seem that further attention could be profitably given to design of the induction and exhaust system to preclude or reduce the number of fires caused by overpriming, backfire, and torching.

Considering only fires in the air, relative order of susceptibility to produce a fire hazard was: (1) accessories, 26%; (2) exhaust system, 22%; (3) fuel system, 17%; and (4) lubrication system, 13%.

(Complete paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Traffic
for Jet

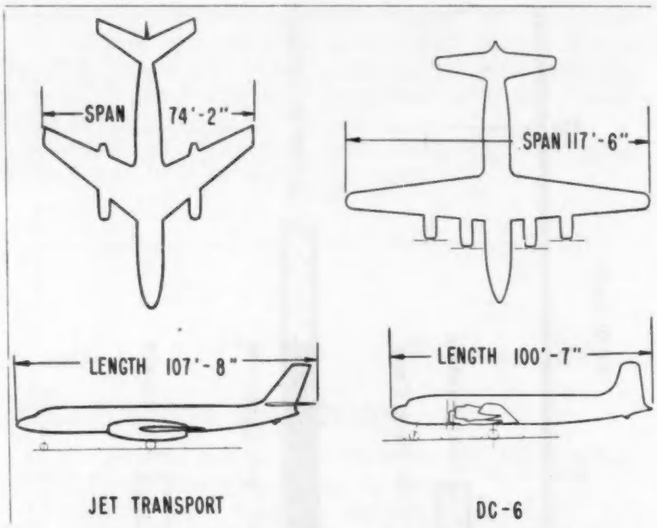


Fig. 1—Hypothetical jet air transport, left, compared with DC-6. Major dimensions are:

	Jet Transport	DC-6
Span (ft)	74.2	117.5
Wing Area (sq ft)	1100	1462
Aspect Ratio	5.00	9.44
Sweepback of 40% Chord Line (deg)	35	0
Max Takeoff Gross Wt (lb)	76,600	93,200
Operating Wt, Empty (lb)	40,400	54,800
Max Continuous hp (rated)	——	4 x 1800
Max Continuous Thrust at SL (lb)	4 x 4960	——

(This paper will be printed in full in SAE Quarterly Transactions.)

JET TRANSPORT aircraft because of their high inherent landing speeds, cannot come into common use until all-weather, all-plane traffic control problems are completely solved.

If they are to be operated economically and safely on regular commercial airways and airports, several new requirements will be imposed on existing air traffic control systems, including the following:

- Permit operation of jet aircraft at their optimum cruising altitudes and/or their optimum climb and descent paths for all flights. Altitudes should be established by the aircraft requirements rather than by the traffic control system factors.
- Incorporate suitable lateral and longitudinal spacing of the control system because of high speeds, and to provide enough maneuvering airspace and eliminate too fequent pilot radio contacts.
- Systems should be able to assign irrevocable landing positions and procedures prior to scheduled descent time from cruising altitudes or highest attained altitudes. When jet planes must be diverted to alternate destinations, this should be done before the scheduled time for descending. Holding procedures, as an integral part of traffic control should be completely eliminated for jet aircraft.
- Control systems must be able to take care of extremely high descent speeds into the airport traffic zones.
- Jet aircraft taxiing and ground running time should never exceed three to five minutes at most.

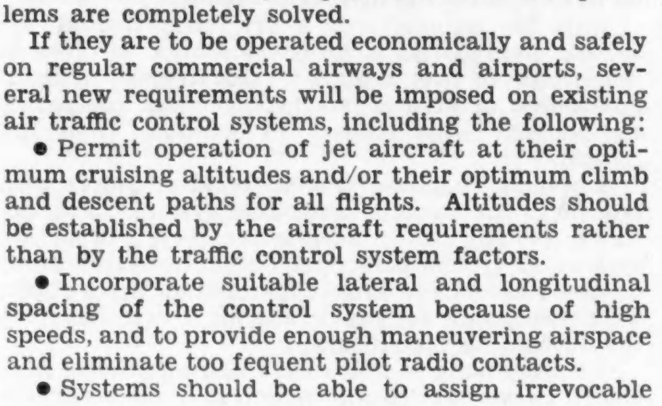


Fig. 2—Jet transport and DC-6 cruising altitude at payloads in lb, assuming 10 mph headwind

The hypothetical four-engine jet transport used in this study has an average cruising speed of 495 mph at its optimum cruising altitude. See Fig. 1 for comparisons of major dimensions of a DC-6 with this hypothetical jet transport.

Jet transports must fly high above the altitudes used by today's propeller driven aircraft, and must be dispatched to cruise at their most favorable altitude to be profitable to operate. The optimum cruising altitude will depend upon the length of trip, wing loading, aspect ratio, and the installed engine characteristics. To maintain lowest cost per 200-lb miles and the maximum payloads, almost the entire flight of about 250 miles and less will consist in climbing and descending.

Varying fuel requirements on payload of the jet transport and DC-6, Fig. 2, show a fantastic comparison. The jet plane can carry a payload of 13,840 lb if the flight is flown at the optimum altitude of between 35,000 and 40,000 ft, but if flown at 10,000 ft would consume more than all the payload. Under comparable conditions the payload variations in respect to altitude are negligible, amounting to only 100 lb in 16,035 lb. Volumetric capacity of the hypothetical jet transport would be about 3650 gal, but the requirement for the trip at 10,000 ft cruising altitude would be 5450 gal.

En route requirements for air traffic control of jet transports will be greatly affected by speed of the aircraft. Radio facilities used and locations must be suitably spaced or the pilot will be spending all his time making position reports and returning radios.

* Paper "Traffic Control Requirements For Jet Transport Aircraft" was presented at the SAE National Aeronautical Meeting, Los Angeles, Oct. 3, 1947.

Control Transports

BASED ON PAPER* BY

Warren T. Dickinson

Assistant to Chief Engineer
DOUGLAS AIRCRAFT CO., INC.
Santa Monica Division

At 495 mph making perfectly coordinated turns with no slip requires these diameters and rates of turn:

Angle of Bank Deg	Diameter of Turn Mi	Rate of Turn deg/min
10	35.2	27
15	23.0	41
20	17.0	55
25	13.2	72
30	10.8	88
40	7.4	129

If we assume the most desirable angle of bank for passenger operation is 15 deg, the minimum possible block length would be 23 miles and if holding was necessary it could be started at one given instant which would be the mid point in the block corrected for wind.

If both right and left turns are permitted on either heading of the airway the minimum lateral separation must be 46 miles—and that gives zero clearance. A 50% safety margin would require 35 mile block lengths and 69 mile lateral separation, and a 100% margin would require 46 and 72 miles, respectively.

Even this 100% safety factor would mean decision time of 2.8 min, because the jet plane would be traveling at 495 mph or 8.25 mpm. Such distances would quickly distort an airways pattern if more than two or three lateral airways are needed to accommodate the traffic.

Because reserve fuel weights for jet aircraft are large as compared with those for reciprocal engine powered aircraft, approach control will prove to be most difficult to solve. Holding and stacking procedures must be eliminated for jet aircraft.

At an intermediate altitude, such as 10,000 ft, reserve fuel for a jet transport would weigh 12,800 lb, while the reserve for the DC-6 weighs 2380 lb, or less than one-fifth.

No startling new traffic control problems are anticipated for jet transports in respect to close-in approach procedures. Due to the swept back wings which decrease maximum lift, and the slightly higher wing loading, stalling speeds are about 25% greater for the hypothetical jet transport than for the DC-6.

Any glide path or other approach suitable for conventional aircraft should be found suitable for jet aircraft provided the additional speed along the path is not too great. Climb outs and balked landings should not offer any particular control problems, although the faster ships will need more air space for maneuvering.

This jet transport has an all engine rated thrust best rate of climb speed of 260 mph, and its climb path angle would be about 8 deg, compared with the DC-6 angle of 5 deg.

Inherent inefficiency of the jet powerplants at low powers introduces taxiing problems. Assuming 600 lb of thrust for taxiing, this jet transport would consume 700 lb of fuel in 10 min, as compared with 140 lb for the DC-6, or less than one-fifth. They may have to be assigned a takeoff position prior to its leaving the ramp. This would call for difficult precision timing and control by the tower operators and pilots at large terminals with mixed traffic.

A serious problem is presented in the high temperature wake of jet aircraft. Fig. 3 shows the high velocities and large areas of high temperatures of jet wake, assuming a 600 lb thrust, power thought to be required for taxiing. At 1.75 specific fuel consumption the jet transport will consume about 700 lb in 10 min in taxiing.

If rated thrust were ever necessary wake velocity would be approximately 100 mph as far as 60 ft behind the engine, presenting a serious hazard to the crew, passengers, airport visitors and other aircraft in the path of the blast. This might mean that jet craft would be towed into and out of airport ramp areas.

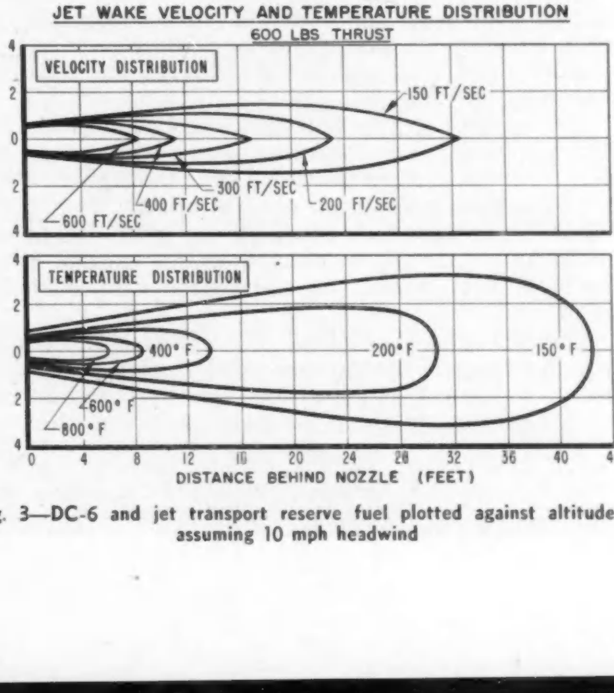


Fig. 3—DC-6 and jet transport reserve fuel plotted against altitude, assuming 10 mph headwind

FLEET MAINTENANCE

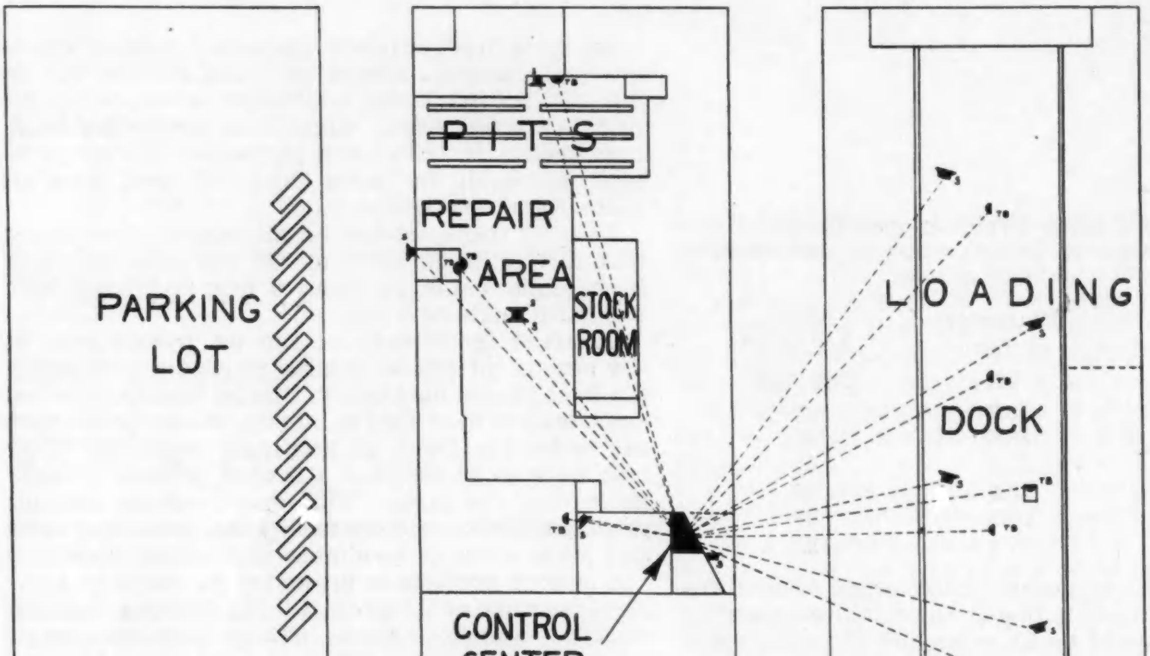


Fig. 1—The equipment coordinator is located at the Control Central. Through an intricate intercommunication system he can contact key personnel in all areas

CONSOLIDATED Freightways uses time and labor-saving production line methods in servicing and repairing its trucks. The system is designed to spot at any time both location and work being done on each truck in the shop. Service and repair set-ups are arranged for rapid, smooth flow of work with no delays in "production" operations.

Let us take a trip through our Production Line Service Plant. Upon arrival of the equipment, the driver releases it to a hostler. Near the sign-in sheet is located the equipment control room. The driver turns the freight bills covering the load over to the coordinator, who is in charge of the control room. He then determines the disposition of the equipment and load.

The driver finishes filling out his truck and trailer logs, noting any mechanical defects or repairs necessary to the equipment. The logs are then turned in to the shop where a job ticket is made, showing driver remarks as well as preventive maintenance operations necessary on the basis of mileage.

The equipment coordinator, after checking the freight bills, makes decision as to disposition of the equipment—either to shop service line, to loading dock, or to city delivery. The equipment coordinator has complete control of the movement of equipment from the time it arrives until it is serviced, loaded, and released to the transport dispatcher.

Coordination Network

Through a very elaborate intercommunication system the coordinator is in constant contact with the service line foreman, general shop foreman, repair area foreman, loading foreman, delivery foreman, freight bill office, dispatcher's office, and several of the loading areas. See Fig. 1. Before him at all times is a large operating board on which the entire area is outlined.

It is his duty to direct every movement of the equipment. No piece is moved except at his direc-

* Paper "Production Line Methods of Service and Repair of Heavy Duty Highway Trucks," was presented at SAE National West Coast Meeting, San Francisco, Aug. 20, 1948.

Patterned After Production Line System

EXCERPTS FROM PAPER* BY **E. B. Ogden**

Superintendent of Shops,
Consolidated Freightways, Inc.

tion. In this manner, it is possible for the coordinator to know where each piece of equipment is at all times. Each department must report to the coordinator when their job is finished so that equipment will move through with dispatch. This coordination system is absolutely essential to the smooth flow of equipment.

Our service line consists of a group of six pits, each 60 ft long, 42 in. deep, 66 in. wide at the bottom, and 42 in. wide at the top. All pits are connected by underground passages, so it is not necessary for the mechanic to climb out of the pit to change from truck to truck. Vise benches are located in the pit passages for the convenience of mechanics. The pits are arranged in three lanes of two each, end to end. The No. 1 pit is the service pit on which all preventive maintenance, service work, tire work, and inspections are performed. The No. 2 pit is the lubrication pit on which all chassis lubrication is performed, gear box and engine oil changed or replenished. The pits are shown in Fig. 2.

Good Lighting Helps

In the service pits flood lights are placed at an angle on each wall at 12-ft intervals (as in Fig. 3). Walls of the pits are painted white. This combination adds that third hand mechanics have always needed. Extending the full length of each pit and running on a track, is a hydraulic jack capable of lifting any one axle under full load. With this arrangement, wheel bearings on the six axles of the

Fig. 2—Preventive maintenance, inspection, lubrication, tire changing, and smaller service operations are performed in these pits. As shown, there are three lines of pits, two pits per line. Each pit is 60 ft long, 42 in. deep, 66 in. wide at the bottom and 42 in. wide at the top

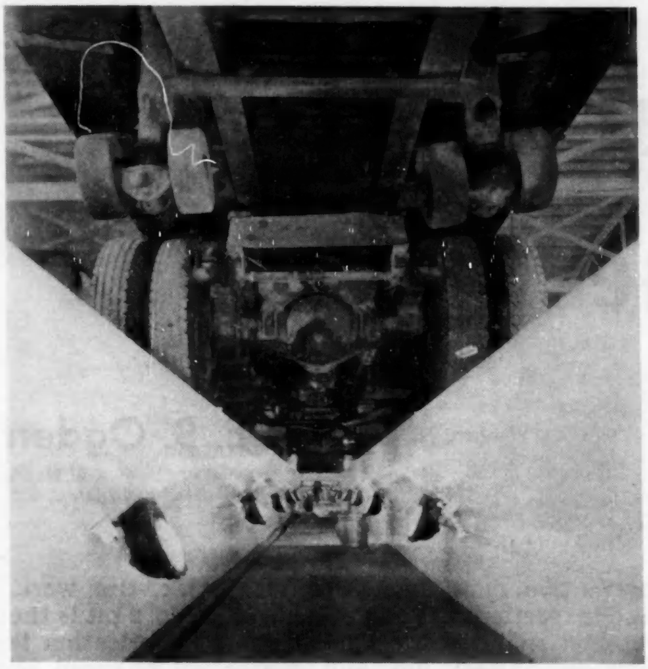
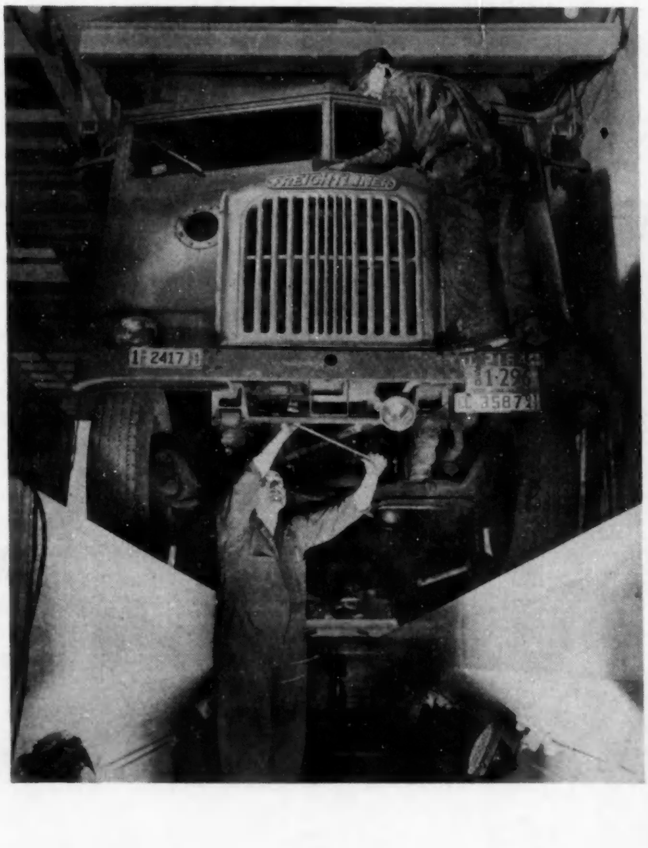


Fig. 3—Proper lighting combined with white-painted walls helps tremendously the mechanic in the pit

Fig. 4—The pits are designed so that mechanics can get at the vehicle with no trouble. A truck is put through the pit service operations in no more than 1 hr and 30 min



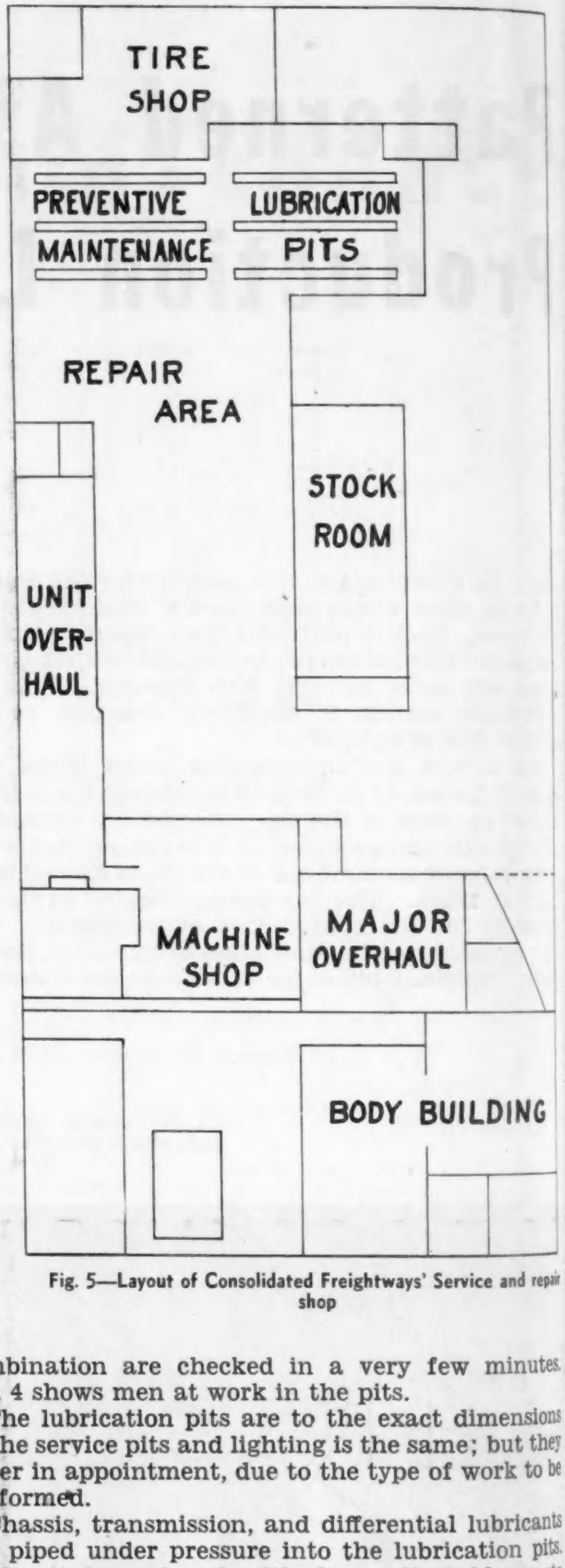


Fig. 5—Layout of Consolidated Freightways' Service and repair shop

combination are checked in a very few minutes. Fig. 4 shows men at work in the pits.

The lubrication pits are to the exact dimensions of the service pits and lighting is the same; but they differ in appointment, due to the type of work to be performed.

Chassis, transmission, and differential lubricants are piped under pressure into the lubrication pits. Each pit is equipped with four adjustable waste oil drain funnels, all of which are connected to underground waste oil tanks. Three of the funnels are for transmission and differential lubricants and one is for engine crankcase drainings. New engine oil, as well as diesel fuel, is piped under pressure overhead at upper floor level, so that filling both the engine and the fuel tank is a simple problem.

The pipe lines carrying the chassis lube and gear oils are heated by steam pipes in cold weather to maintain uniform flow. All lubricants, except chassis lube and wheel bearing grease, are stored in underground tanks from which they are pumped to the lubrication pits.

The entire area of the upper floor and the pit floors are heated by the "radiant heat" method, which consists of a series of pipes laid in the concrete floor through which hot water is pumped. This method of heating shops is by far the most satisfactory in our experience.

To receive full benefit of the pits, it is necessary to limit the amount of work performed on the pit. Too lengthy a pit operation would put this particular line out of production for smaller jobs behind, interrupting the flow. Shop layout is shown in Fig. 5.

To avoid this, we have limited the use of the pits to preventive maintenance, inspection, lubrication, changing of tires, and smaller service operations. We have set a time limit—from the time equipment enters the service line until it is completed, including lubrication—of 1 hr and 15 min to 1 hr and 30 min.

As equipment moves over the service line, all defects observed are recorded on the job ticket. Those that are small and can be performed in the time allotted are completed on the pits; those that require more time are completed in the repair area in another part of the building. In the repair area, work is confined primarily to changing units such as brake shoes and drums, transmissions, differentials, engines, air compressors, and cylinder heads. In this area, also, minor body and cab repair is performed at the same time other units are being worked on. Our aim is to utilize all the time the equipment is in the shop to the greatest advantage.

Units removed in the repair area are reconditioned in another department called the unit repair area.

Repairs Specialized

To maintain an even flow of units, the entire unit repair area is divided into sections in which all repair work is specialized; sections are specially equipped for reconditioning engines, air equipment, electrical equipment, fuel pump and injector equipment, and transmission and differential units. Extending full length of this area and connecting with a wash rack and disassembly room is an electric monorail crane.

As units are removed from the equipment in the repair area, they are routed via electric crane to the disassembly room, to the wash rack, and then to the specialized unit repair section.

After reconditioning, the units are routed to the parts room where they are again issued to the repair area as needed.

Adjacent to the repair area is a well-equipped machine shop and also an area devoted entirely to major chassis repair work, which required more time than can be allotted in the repair area.

Major van body repair is handled in the body repair department, adjacent to, but not connected with, the chassis repair area. See Fig. 5.

Before equipment is placed in the chassis repair area, the van body is thoroughly inspected. If it requires any major repair, the body is removed and placed in the body department. In this way we take full advantage of all the time equipment is out of service.

Service Based on Mileage

Our preventive maintenance is based entirely on road mileage schedules. This is adhered to religiously as set up on the forms we use for outlining preventive maintenance periods and for recording and compiling mileage. This does not mean, however, that we do not examine each predetermined service mileage periodically to determine if the mileage can be extended or should be reduced. We have been very successful in extending the service periods.

Through our system of records, we are able to determine the interval between overhaul of virtually all units such as engines, transmissions, differentials, air compressors, and fuel pumps, as well as the life of brake linings and drums. By close observation of units changed due to reaching the mileage period, and close analysis of road failure frequencies, we can determine the average mileage we may expect from various units.

(Complete paper on which this article is based in available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

CRC Reports

Revised List Available FREE

Coordinating Research Council reports are now in stock and ready for distribution. Since the printing of the list in the November SAE Journal, there have been a number of changes in availability of individual items.

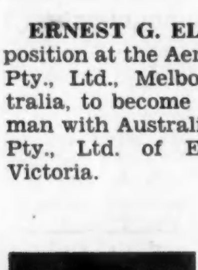
A new list, including prices, has been prepared and will be sent free on request.

About

RUSSELL S. BEGG is chief engineer of General Motors-Holden's Ltd., Australia, which has just announced it is starting production of the first Australian-built car—the Holden. The Holden is of integral body-frame construction and weighs 2230 lb. It has a 103-in. wheelbase, 172 in. overall length, 54-in. rear tread, and an 8½-in. minimum clearance. Overall car height is 61-11/16 in. The 15-in. wheels carry 5.50 × 4-ply low-pressure tires. The Holden's 6-cyl overhead valve engine has a 132.5 cu-in. displacement. It is rated at 21.6 hp and develops 60 bhp. It is claimed that the car averages better than 30 miles per American gallon. Begg is shown at far left.

ERNEST G. ELLIS has resigned his position at the Aeronautical Supply Co., Pty., Ltd., Melbourne, Victoria, Australia, to become senior design draftsman with Australian National Airways, Pty., Ltd. of Essendon Aerodrome, Victoria.

CHARLES H. ZIMMERMAN recently became aeronautical research scientist for the National Advisory Committee for Aeronautics at Langley Field, Va. He had been consulting engineer with Chance Vought Aircraft Division of the United Aircraft Corp., Stratford, Conn.



F. C. PATTON has been appointed general superintendent of Passenger Service for the Pacific Electric Railway Co. in Los Angeles. He was formerly manager, Los Angeles Motor Coach Lines. Patton is a past councilor and has been an SAE member since 1927.

J. V. BASSETT, chief sales engineer of the Heavy Duty Friction Material Division, Raybestos-Manhattan, Inc., has been transferred from the Passaic Office to the Equipment Sales Division Equipment Headquarters in Detroit. He has had many years of experience with rubber and friction materials, having been with the Manhattan Rubber Division for 25 years.

ABBOTT L. JOHNSON has been elected president and general manager of the Asbestos Mfg. Co. in Huntington, Ind. In addition to this new post, he is also president and general manager of Warner Machine Products, Inc., and vice-president and director of the Glascock Bros. Mfg. Co., Muncie, Ind.

H. O. MOELLER has reorganized the Stores and Purchasing Departments at the Key System Transit Lines in Oakland, Calif., and has now become general superintendent of automotive equipment, as the company has discontinued the use of all street cars. They now have 656 coaches in operation, both gasoline and diesel.

HOY STEVENS, chief of Equipment & Operations Section, American Trucking Associations, Inc., Washington, D. C., lectured before the Third Annual Motor Vehicle Maintenance Supervisors Short Course, Nov. 5, at The Pennsylvania State College, and again on Nov. 18 before the First Annual Seminar on Problems and Policies of Motor Vehicle Fleet Management on Safety Supervision, New York University. He is past-chairman of the SAE Washington Section.

ROBERT C. JUVINALL has become assistant professor of mechanical engineering, Machine Design Group, at the University of Illinois in Urbana, Ill.

JOSEPH E. WHITFIELD has been made project engineer at the Standard Stoker Co. in Erie, Pa. Previously he had been connected with the General Machinery Corp. in Hamilton, Ohio.

W. W. CONSTANTINE, G. H. LANCHESTER and **L. J. SHORTER**, are SAE members who have been elected to the Automobile Division Council of the Institution of Mechnical Engineers in London, England.

CHARLTON F. MILLS is now associated with the Pierce Governor Co., Inc., Anderson, Ind., as district representative for the Detroit area. He had been service engineer for the Fuel Injection Division of the Ex-Cell-O Corp.

CHESTER C. DE PEW, for the past 12 years chief design engineer of Ranger Aircraft Engines Division, Fairchild Engineering & Airplane Corp., Farmingdale, L. I., N. Y., has been appointed consulting engineer of the company, reporting to **A. T. GREGORY**, chief engineer.

Members

WILLIAM H. BEAN, for a number of years a maintenance engineer for the Third Avenue Transit System and an authority on diesel engines and their maintenance, has been appointed head of the Mil-Jay Sales Co., 1775 Broadway, New York City. He has been a member of the SAE Metropolitan Section Governing Board and has headed the Diesel Engine Activity of the Section.

JOHN FITZ HILL is now an instructor in the Mechanical Engineering Department at Rensselaer Polytechnic Institute, Troy, N. Y. He had been laboratory engineer at Chrysler Corp. in Highland Park, Mich.

JAMES POSAVAC is now part owner of the Illinois Butane Gas & Equipment Co., Inc., located in Bloomington, Ill. He is treasurer and also an engineer for installation and maintenance of equipment. He also does product and design engineering for a few industrial companies in the Bloomington area. Posavac recently resigned as product and design engineer at the Weatherhead Co. in Cleveland, Ohio.

CLIFTON A. WARNER, heretofore affiliated with Continental Aviation & Engineering Corp. in Detroit, Mich., has now become products application engineer for the Clinton Machine Co., Clinton, Mich. In his new post he will cover the United States, working directly with manufacturers of products such as farm implements, lawn mowers, and pumps, requiring gasoline engine power for their products.

HENRY G. KAYE is now co-owner of the Electronic Heat Treating Co. in Muskegon, Mich. He holds the post of secretary-treasurer. He is on the 1948-49 Reception Committee of the SAE Western Michigan Section.

DAVID JUKOFF has become assistant project engineer at the Curtiss-Wright Corp. in Caldwell, N. J. Previously he had been an aeronautical research scientist for the National Advisory Committee for Aeronautics at Moffett Field, Calif.

JAMES D. THACKREY has become research engineer at the Jet Propulsion Laboratory of California Institute of Technology in Pasadena, Calif.

MAJOR FREDERICK M. McCULLAGH is now technical staff officer for the Directorate of Mechanical Engineering, War Office, London, England.

ALFRED M. MORROW has become a junior mechanical engineer for the Board of Transportation of the City of New York. He had been junior experimental engineer, Le Roi Co. in Milwaukee, Wis.

C. M. PETER was recently elected vice-president and general manager of the Fellows Gear Shaper Co. in Springfield, Vt.

WILLIAM J. NUSBAUM, prior to becoming aeronautical research scientist for the National Advisory Committee for Aeronautics, Cleveland, Ohio, was designer and physicist at Continental Motors Corp. in Muskegon, Mich.

FRANK WOOLEY, formerly commercial manager of Parrs (Leicester) Ltd., Leicester, England, has joined Trucks, Tractors & Equipment, Ltd., Johannesburg, South Africa. He has been team manager for the British racer F. R. Gerard in a remarkable series of races in a 12-year old ERA racer in Ireland, Belgium, Isle of Man, and England.

J. V. RETTIG recently resigned his position as field service engineer for the Motch & Merryweather Machinery Co. He has entered the machinery field with his own business under the firm name of Rettig Machinery Co. The new firm will be located in Dayton, Ohio, at 4330 Shenandoah Drive.

JAMES K. FULKS, left, is now a director of the Ex-Cell-O Corp. and D. H. McIVER, right, is now sales manager of the Precision Products Division. Fulks started to work for this firm after his graduation from Ohio Northern University in 1925. In 1940 he was made factory manager of all Ex-Cell-O plants and in 1942 was promoted to vice-president in charge of manufacturing. McIver joined the company in 1929 after he graduated from Ohio Northern University and he has served in the Shop, Production Planning, and Sales Departments

SAE Fathers and Sons . . . . .

At right is **GEORGE M. HOLLEY**, chairman of the board at Holley Carburetor Co. in Detroit. His two sons are also affiliated with him at this company. Lower left is **JOHN C. HOLLEY**, administrative department and, top, **GEORGE M. HOLLEY, JR.**, executive vice-president of the company. The elder Holley is a long-standing member of the SAE, having joined in 1909.

Another Father and Son who are in business together are **WALTER A. OLEN**, who is president of the Four Wheel Drive Auto Co. in Clintonville, Wis., and his son. The son, **D. B. OLEN** is director of the Engineering Division of that company. Walter Olen has been an SAE member since 1922.

CARL F. HIGH, who has been connected with Ex-Cell-O Corp., Detroit, is Ex-Cell-O representative on fuel injection equipment for tractor, truck, bus and other spark-ignited automotive engines in the states of Michigan, Ohio, Indiana, Illinois, Wisconsin and Minnesota. **JOHN RICHARD HIGH**, his son, is an Ensign in the U. S. Navy. He completed the Navy V-12 Course at M.I.T. in 1946, and received a B.S. degree in Aeronautical Engineering. His responsibilities are communications officer and electronics repair officer on the U.S.S. Raby (DE 698).

CHARLES F. KETTERING was guest of honor at the recent celebration marking the ninth anniversary of the Automobile Old Timers. It was held in New York City on Nov. 9.

VERN C. MARKLEY, JR., is now sales engineer for Grand Haven Stamped Products in Grand Haven, Mich. Prior to that post he held a similar position with Graham-Paige Motor Corp., Willow Run, Mich.

D. FRANKLIN BOYD recently became quality control analyst for the Detroit Engine Division of the Kaiser-Frazer Corp. He had been a project engineer for the Univis Lens Co. in Detroit.

WITOLD S. GWIZDOWSKI recently became a mechanical engineer at the Automotive Stamping Mfg. Co. in Detroit. He was formerly a mechanical engineer with the Colonial Broach Co.

DEAN L. FISHER, formerly with Howe Brothers, Troy, N. Y., has organized a firm under his name to design and build specialized truck equipment at 632 Main Street, Rockland, Maine.

ROBERT A. SCHROEDER, JR., formerly a contractor in Highland Park, Mich., and previous to that a mechanical engineer for the Detroit Arsenal, Army Ordnance Department, has joined Willys-Overland Motors, Inc., Toledo, as engineer with the Econorama project which consists of three dimensional graphic units depicting economics and fundamental laws of business.

CHARLES L. BEST is an instructor of mechanics at Lafayette College in Easton, Pa.

MARION COLE TRAVIS, now a chemist for the American Grease Stick Co. in Muskegon, Mich., had previously been assistant service engineer for the Sealed Power Co., same city.

HOWARD F. FRITCH has been appointed president of the New England Transportation Co. and assistant to the president of the New Haven Railroad. He will be located in Boston.

CARL T. DOMAN, who is vice-president and chief engineer of Aircooled Motors, Inc., is also one of the founders of a new company in Syracuse, N. Y. The new firm name is Pattern Makers, Inc. They will build wood and metal patterns for the trade and as business warrants the firm will be greatly enlarged.

HARRY SAIDLER LEE is now an aeronautical engineer for the Curtiss-Wright Corp. in Columbus, Ohio.

BEHRAM DOCTOR is now located in Bangalore, India, doing work as a consultant for road transport and automobile engineering.

HARVEY S. FIRESTONE, JR., right, chairman of the Firestone Tire & Rubber Co., has received the Cross of Chevalier of the Legion of Honor awarded by the French government in recognition of his outstanding service to agriculture throughout the world. The award was presented by J. J. Viala, left, Consul General of France. The award was established by Napoleon Bonaparte in 1802. The Legion of Honor is the only official honors organization of the French Government

SAE Members Said . . .

DR. T. P. WRIGHT, vice-president for research at Cornell University spoke on "The Role of the University in Research" at the Cornell Club in New York City on Dec. 2. He said that Cornell now has $6,000,000 in contracts for government-sponsored applied research to be carried out in the Aeronautical Laboratory in Buffalo. This is 60% of the budget for aeronautical research; 35% is industry sponsored and only about 5% regular university fundamental research.

ALFRED P. SLOAN, JR., was honored on Nov. 30 by 80 national and state leaders for his service to highway transportation at a National Highway Users Conference meeting. He said an expanding highway system is fundamental to America's industrial expansion. He viewed as encouraging, for the "next two or three years," the nation's economic prospects.

"The so-called dollar shortage is really only a nice-sounding name to hide the fact that paper currencies are not worth what they once were, either in internal or foreign purchasing power. All of the foreign paper currencies are in disrepute even with their own nationals because they are known to bear a false, or at least unknown, relationship to gold." . . . "Nobody knows exactly what these foreign currencies are worth in relation to each other, in relation to the American dollar, or to gold. And nobody will know what these currencies are worth until we have free markets for gold, for gold is the common denominator for all money and commodity values." . . . **JAMES D. MOONEY**, president and board chairman of Willys-Overland Motors, at the Commonwealth Club in Toledo Ohio, Nov. 12.

JOHN W. B. PEARCE has retired from the Spicer Mfg. Division of Dana Corp. after nearly 44 years of service with this company. His position was chief engineer of Spicer's universal joint division. He started working with C. W. Spicer in Plainfield, N. J. in 1905, as a draftsman.

SAE members who have been elected to membership on the Board of Directors of Automotive & Aviation Parts Manufacturers, Inc. are: **L. M. CLEGG**, executive vice-president, Thompson Products, Inc.; **D. H. KELLY**, executive vice-president, The Electric Auto-Lite Co.; and **J. L. MYERS**, president, Cleveland Graphite Bronze Co. Their new officers for 1949 are: president, **M. P. FERGUSON**, Bendix Aviation Corp.; vice-president, **R. H. DAISLEY**, Eaton Mfg. Co.; and secretary-treasurer, **J. L. MYERS.**

GLENN J. BUNDY is now owner and operator of Simplex Piston Ring Service in Pasadena and surrounding territory. In the past he served Electric Auto-Lite for 18 years and Monroe Auto Equipment Co. for 2 years.

WILLIAM CONRAD JORDAN has been elected president of both Curtiss-Wright Corp. and its subsidiary, Wright Aeronautical Corp., succeeding **GUY W. VAUGHN** who was named chairman of Curtiss-Wright and will continue as chairman of Wright Aeronautical Corp. Jordan, who has had 24 years of aeronautical engineering and production experience was brought into the Wright organization by Vaughn following World War II. He was formerly vice-president and general manager of Steel Products Engineering Co., Springfield, Ohio, aircraft equipment manufacturers. He had been vice-president and general manager of Wright Aeronautical Corp.

H. H. KELLEY, head of the U. S. delegation to the United Nations Economic Commission for Europe, submitted to that organization a draft of an agreement to govern size and weights of vehicles in international highway transportation at the recent meeting in Geneva, Switzerland. Proposed maximum dimensions for trucks and buses were: Width, 96 in.; height, 11 ft 6 in.; length of single vehicle, 32 ft 9½ in.; total permissible length of truck and trailer, 72 ft 2 in.; weight on each axle, 17,600 lb.; total permissible weight, 70,500 lb. These limits are far below the original European proposals which would have increased the cost of highway maintenance 30%, according to Kelley who is special adviser to the U. S. Department of State on transport communications.

PETER J. MILLER has been appointed general manager of the Bus Heater Division at Toledo Heat Co., Toledo, Ohio. He was formerly connected with the Evans Products Co., Detroit, as assistant works manager.

OBITUARIES

W. J. BLANCHARD

Werner J. Blanchard, general manager of Aeroproducts Division, General Motors Corp., was killed Dec. 4 when his private plane crashed ten miles west of Columbus, Ohio. Two passengers, employees of his company, were also killed.

Blanchard was active in SAE technical and administrative affairs, also in activities of the Dayton Section for many years. Last year he served as Meetings Chairman of the Aircraft Powerplant Committee and had devoted a great deal of time with his characteristic energy to one of the most successful years that Activity has ever enjoyed. He was vice-president elect of the Society for the Aircraft Powerplant Activity.

In 1935 he and a group of former engineers of Curtiss Propeller Division, Curtiss-Wright Corp., began to develop several new ideas for aircraft propellers. About five years later, when the propeller developments had been flight tested, General Motors Corp. acquired them and built the modern Aeroproducts plant at Vandalia, near Dayton, Ohio.

A Kansan by birth, "Pete" graduated from Kansas State College in 1924, and studied advanced machine design at the University of Wisconsin for the next two years.

He joined Curtiss Airplane Co. in Garden City in 1927 and soon headed a department to develop propellers for that company, by then the Curtiss Airplane & Motor Co.

During the pre-Pearl Harbor SAE aeronautical standards work, Blanchard and his associates were extremely generous with their time on propeller phases of the program, and continued their interest during the war and throughout the postwar period.

EUSTACE B. MOORE

Eustace B. Moore died at his home in La Crescanta, Calif. on Nov. 5, following a heart attack suffered the previous day. He had been building a fence around his home.

He was retired from service with the L. A. Automotive Works, Los Angles, after 30 years of service, starting with L. A. Creamery, then Golden State Co. and finally with the L. A. Automotive Works. He had been manager of that company.

Moore is a past chairman of the SAE Southern California Section and had been a member of the SAE since 1917. He was 67.

ALAIN MADLE

Alain Madle,chief electrical engineer for the Briggs & Stratton Corp., passed away on Oct. 21.

He had been with Briggs & Stratton since 1939. He had helped develop the transitorq, a variable speed transmission for the General Motors Corp. and Graham Transmission, Inc. Before joining the Briggs & Stratton Corp, he had worked for the Graham firm for three years. He was with the General Motors Corp. division at Bristol, Conn., from 1927 to 1935.

Madle was 57. He joined the SAE in 1946.

GEORGE W. SMITH

George W. Smith recently passed away very suddenly.

He was a special representative of Standard Oil Co. of Calif. and served as a consultant on fuels and lubricant problems in that area. He had been employed by Standard Oil for 25 years.

Smith had been a member of SAE since 1944.

B. M. LEECE

Bennett M. Leece, president of Leece-Neville Co., Cleveland, a pioneer in the automotive lighting and starting equipment design and manufacture, died Dec. 5. He was 72 years old.

He began his career as a shop foreman in an electrical supply firm before the turn of the century, and was a founder of the company as chief engineer in 1909. He joined the SAE in 1913, and in the earlier years was active in electrical standards work of the Society.

His company was credited with the development of the two-unit starting and lighting equipment for automobiles, and developed and manufactured the first practical automotive voltage regulator.

During World War II his company manufactured electrical devices for aircraft, PT boats, submarines, and other equipment, and was the only supplier of some of the critical parts.

About two years ago he started development work on AC systems for motor vehicles.

TECHNICAL COMMITTEE PROGRESS

SAE TECHNICAL BOARD

J. C. Zeder, Chairman

W. G. Ainsley	William Littlewood
B. B. Bachman	Arthur Nutt
L. Ray Buckendale	G. A. Page, Jr.
J. M. Crawford	W. D. Reese
W. P. Eddy, Jr.	D. G. Roos
Charles Froesch	C. G. A. Rosen
C. E. Frudden	S. W. Sparrow
W. H. Graves	R. L. Weider
R. M. Insley	D. K. Wilson
G. W. Laurie	V. C. Young

Harold T. Youngren

Road Friction Measuring Methodized by SAE Group

A newly-issued report of the SAE Highways Research Committee presents a procedure evaluating friction qualities of road surfaces under varying conditions. The report, entitled "Coefficient of Friction Between the Tires and the Road," spells out a method for measuring the road coefficient of friction.

Problem of determining this coefficient—from the standpoint of the road rather than the tire—came to the Committee's attention because of the wide divergence of results obtained for a given road surface under given conditions. The values vary with both method of measurement and equipment used, reports Committee Chairman A. M. Wolf.

In an effort to develop a uniform procedure to get correlation between results of different tests and different investigators, the Committee studied data from numerous tests. The result: a method which the Committee believes yields reproducible results. It is detailed in the report.

In addition to the method prescribed for measuring the coefficient of friction for dry and wet surfaces, the report presents values of the coefficient of friction obtained over various types of road surfaces under different conditions. (The report (SP-55) is available from the SAE Special Publications Department. Price: 50¢ to members, $1.00 to nonmembers.)

Serving with Chairman Wolf on the SAE Highways Research Committee, which authored the report, are: B. B. Bachman, Autocar Co.; D. S. Berry, University of California; C. H. Bolin, Pacific Tele-

phone and Telegraph Co.; R. W. Brown, Firestone Tire & Rubber Co.; H. C. Dickinson, National Bureau of Standards; R. D. Evans, Goodyear Tire & Rubber Co.; F. L. Faulkner, Nelson Chevrolet Sales, Inc.; F. C. Horner, General Motors Corp.; W. E. Lay, University of Michigan; B. J. Lemon; A. A. Lyman, Public Service Coordinated Transport; R. A. Moyer, University of California; T. L. Preble, Tide Water Associated Oil Co.; C. P. Roberts, Ohio State University; V. J. Roper, General Electric Co.; K. D. Smith, National Standard Co.; T. C. Smith, American Telephone & Telegraph Company; and K. W. Stinson, Ohio State University.

Technishorts . . .

CASTING DESIGN: Fundamentals of Casting Design, a report being planned by a division of the SAE Iron & Steel Technical Committee, will tell the designer what he should know about foundry practice and techniques. Members of the group, headed by R. A. Flinn, American Brake Shoe Co., will aim the report at working designers who lack this knowledge to submit intelligent specifications and to take advantage of more workable design. Among the points considered for inclusion in the report are: information on proper mold and pattern design, application of various alloys, how to reduce scrap, and heat-treatment and its effect on machinability.

PROP SHAFT ENDS: At the request of the Aircraft Industries Association, the SAE Propeller Standards Committee and the SAE Committee on Standard Components for Aircraft Engines prepared tentative standards for dual rotating propeller shaft ends. Designated Nos. 65-80 and 80-90, these standards cover propeller shaft ends for high horsepower engines, including turboprops. These combinations better satisfy power requirements than previously proposed combinations 80-90 and 90-100. Sizes 70-90, 70L-90, 80-100, and 80L-100 will be removed from ARP 375 and sizes 65-80 and 80-90 added to it.

SHOT PEENING: R. L. Mattson, Chairman of the Shot Peening Division, SAE Iron & Steel Technical Committee, reports that his group has outlined the manual it intends to write on the shot peening process. Main objective of the treatise is to bring to engineers and shop men the possibilities and limitations of shot peening. The manual will include a description of the process, its effects, equipment, description of shot types and sizes, specifications, production procedures, and inspection.

SPARK ARRESTERS: To eliminate the fire hazard in wooded areas or near inflammables from sparks discharged in diesel engine exhaust, the SAE Spark and Flame Arrester Committee is searching for materials suitable for simulating sparks. These materials will be introduced into the engine inlet and action of these particles at the exhaust will be observed. It is planned to place spark arresters on engines and visually observe their effectiveness in eliminating sparks.

CORROSION RESISTANCE: Publication of a report on corrosion-resistant coatings and procedures in the 1950 SAE Handbook is aimed for by a division of the SAE Iron & Steel Technical Committee, under R. E. VanDeventer, Packard Motor Car Co. Also to be included in the report is a discussion of materials selection and corrosion proofing for both function and appearance.

REAR VIEW MIRRORS:The Automobile Manufacturers Association has requested the SAE Technical Board to develop specifications for rear view mirrors if SAE studies indicate that useful specifications are possible. The SAE Body Engineering Technical Committee will study the problem for the Technical Board and will report back to the Board as to whether it believes useful specifications can be developed.

BRITISH STANDARDS: In its British Standards for the Automobile Industry, 1948 Edition, the British Standards Institution has included SAE standards for involute splines and involute shaft serrations. With regard to these SAE standards, the foreword to the British Handbook says, "It was felt that the inclusion of these would be useful in view of the close link which exists between the American and British motor industries, a link which it is hoped will be maintained."

Safety Glass Code Envelopes New Type

RECENT revision of American Standard Z26.1—for motor vehicle safety glass—covers tests for heat-absorbing glass used in air conditioned vehicles operating in high-temperature service. SAE is represented on the ASA Sectional Committee on Specifications and Methods for Test of Safety Glass, Z26.

The original discoloration test required the glass sample to transmit 70% of full radiance after exposure to ultra-violet radiation (simulating sunlight). But heat-absorbing glass for buses operating in tropical regions transmits less light than ordinary types of safety glass. For this reason test requirements for cars and buses required a higher percentage of light transmittance after the test than was practical for heat-absorbent glass.

American Standard Discoloration Test for Safety Glass, Z26.1a-1948, the revised test, takes cognizance of this fact by permitting a lower percentage of light transmission (50% minimum) for safety glass in side and back motor vehicle windows.

Better Quality Control Aim of Drafting Group

THE SAE Aeronautical Drafting Manual Committee is at work developing a way for draftsmen to specify on a drawing concentricity, parallelism, and squareness of a part so that it will be checked properly. This will eliminate erroneous rejection of acceptable parts and acceptance of parts machined outside of dimensional limits—a pitfall of improper inspection methods.

Proper inspection technique for these relationships of surfaces to each other is particularly important for parts like crankshafts.

Investigations conducted by the Committee show that checking the part on centers gives true differences in concentricity, parallelism, or squareness between two surfaces. Checking the part on one or two V-blocks introduces errors. It is possible to reject a good part and to accept parts closer than limits of the drawing by checking in V-blocks.

The Committee hopes to develop a special note relating to a common center. This will give concentricity, parallelism, and squareness on all surfaces if the part is revolved around a common center or its equivalent. Such a note is intended to replace individual notes for each surface characteristic which usually are contradictory.

CALENDAR

Canadian—Jan. 19

Roof Garden—Royal York Hotel—Toronto, Canada. Dinner 7:00 p.m. "Revolutionary Developments on Military Wheel Vehicles"—Col. J. M. Colby, Chief of Development and Designing, Detroit Arsenals, U. S. Army, Center Line, Mich.

Chicago—Jan. 17 South Bend Division

Hotel LaSalle, South Bend, Ind. Dinner 6:45 p.m. Meeting 8:00 p.m. "Passenger Car Engine Powerplant Mountings"—E. F. Riesing, Firestone Industrial Products Co.

Cincinnati—Jan. 24

Quebec Road Garden; dinner preceding plant visit of Queen City Steel Treating Co.

Cleveland—Jan. 17

Cleveland Club; dinner 6:30 p.m. "Packaged Nuclear Power Plants"—Dr. J. A. Campbell, Asst. Professor of Chemistry, Oberlin College. Speaker Sponsor—T. R. Thoren, Thompson Products, Inc.

Detroit—Jan. 31

Large Auditorium, Rackham Educational Memorial—"Light Weight Air Cooled Engines for Vehicles"—C. F. Bachle, vice-president, Charge of Research, Continental Aviation & Engineering Corp. Meeting 8:00 p.m.

Metropolitan—Jan. 20

Hotel Pennsylvania; meeting 7:45 p.m. Joint meeting with American Welding Society. Talk on Welding Problems Encountered in the Automotive Industry—John Randall, Ford Motor Co., Edgewater, N. J.

Mohawk-Hudson Group—Jan. 19

Hotel Wellington, Albany, N. Y.; dinner 6:45 p.m. Economics Shape Truck Trend—Merrill C. Horine, Mack Mfg. Corp.

Northern California—Jan. 27

Stanford University—Dinner will precede meeting. Student Papers Student Meeting.

Northwest—Jan. 7

Hotel Gowman, Seattle, Wash.; dinner 7:00 p.m. Practical Metallurgy—As Applied to the Automotive Industry—Leon Olberg, metallurgist, Morley Magnesium Foundry.

Philadelphia—Jan. 12

Engineers Club, Philadelphia; dinner 6:30 p.m. Meeting 7:45 p.m. Telephones on Wheels—Mr. McGrath, Bell Telephone Co. Technical chairman: Howard L. Davis, Philadelphia Electric Co.

Pittsburgh—Jan. 25

Dinner—Webster Hall Hotel at 6:30 p.m. Meeting—Mellon Institute Auditorium 8:00 p.m. "Cold Rubber"—speaker will be representative of Mansfield Tire & Rubber Co.

St. Louis—Feb. 3

Engineers Club, St. Louis; meeting 8:00 p.m. Joint meeting with Engineers Club of St. Louis. What America Can Get in a Light Car—D. G. (Barney) Roos, Willys-Overland Motor Co.

Southern California—Jan. 18

Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles; dinner 7:00 p.m. Fuels—Their Present and Future Utilization—W. M. Holaday, director, Socony-Vacuum Laboratories.

Spokane-Intermountain—Jan. 15

Trentwood Plant Permanante Metals Co. Luncheon 1 p.m. to be followed by inspection tour of plant.

Western Michigan—Jan. 20

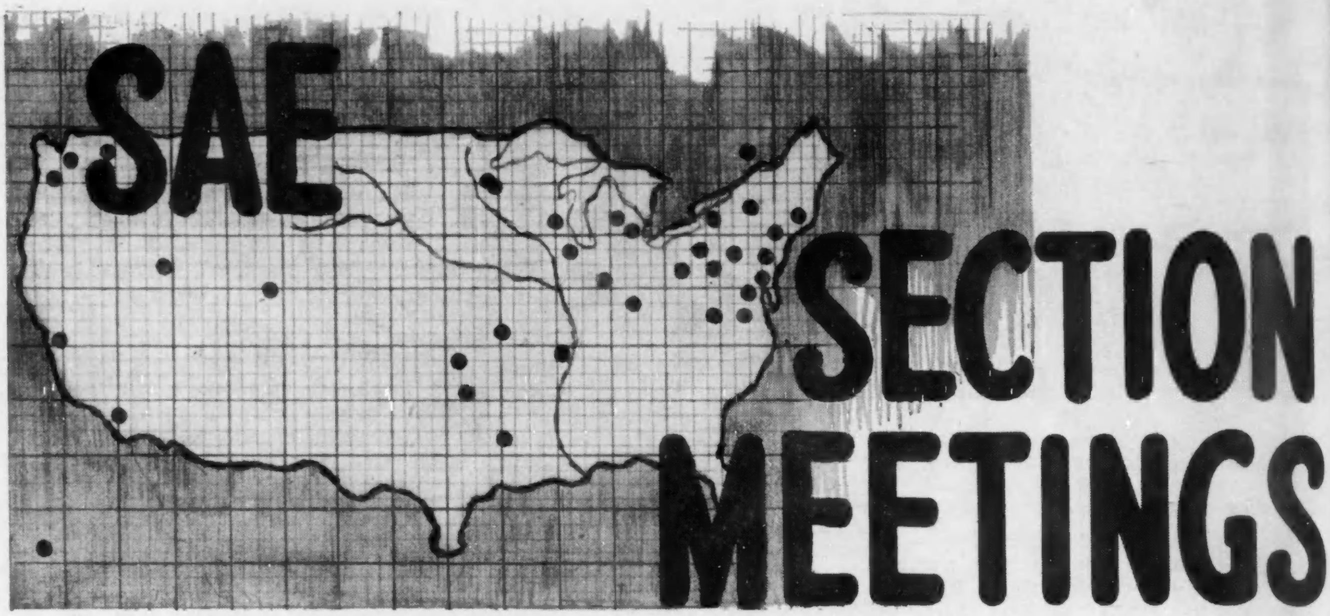
Hackley Art Gallery, Muskegon, Mich.; meeting 7:45 p.m. Industrial Armament and Preparedness—David J. Vail, vice-president, Campbell, Wyant & Cannon Foundry Co. Movie provided by Standard Oil of Ind.—Gasoline's Amazing Molecules.

Williamsport Group—Jan. 10

The Anglers Club, Williamsport, Pa.; dinner 6:45 p.m. The Training of Personnel in the Operation and Maintenance of Diesel Locomotives—F. Thomas, assistant to general superintendent, Motor Power Rolling Stock of the New York Central System.

NATIONAL MEETINGS • 1949

MEETING	DATE	HOTEL
ANNUAL MEETING and Engineering Display	Jan. 10-14	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and PRODUCTION	March 8-10	Book-Cadillac, Detroit
TRANSPORTATION	March 28-30	Statler, Cleveland
AERONAUTIC and AIR TRANSPORT and AIRCRAFT Engineering Display	April 11-13	New Yorker, New York
SUMMER	June 5-10	French Lick Springs, French Lick, Ind.
WEST COAST	Aug. 15-17	Multnomah, Portland, Oreg.



Railroad Diesels Topic at Syracuse

—W. F. BURROWS, Field Editor

SYRACUSE Section, Nov. 9—Cornell University played host to the Section at a meeting which explored problems of diesel-electric locomotives from the manufacturers' and the users' viewpoints.

C. A. Trimmer, consulting engineer for the American Locomotive Co., described design features of the Alco engines used in diesel-electric locomotives and major features of the locomotive as well.

F. T. James, general superintendent of motive power and equipment, Delaware, Lackawana, and Western Railroad, covered his road's operating problems.

The meeting was preceded by a dinner on the Cornell campus and a tour of the university's diesel-engine laboratory.

Diesels' Future Bright In Mass Transit Field

—A. M. WATSON, Field Editor

SOUTHERN NEW ENGLAND Section, Nov. 4—Diesel engines are not expected to threaten the pre-eminence of the gasoline engine in motor transport generally, but they will probably gain the mass transit business, according to Merrill C. Horine, Mack Mfg. Corp.

Fuel economy of the diesel powerplant has always been its chief claim, but diesels must measure up to American standards of smoothness, lack of smoke and unpleasant odors, flexibility, and quietness.

In this country gasoline and diesel fuels are so nearly equal in price that principal savings must be shown in miles per gallon, he pointed out.

Types of diesel engine acceptable in Great Britain and on the continent would not be tolerated in this country because of their limited power, generally rougher performance, and lack of economy.

Transit buses on city routes face the most exacting demands, and the American diesel has measured up to these, and more of them are in this service than any other in this country.

Diesel powerplants add about $500 to the cost of a 41-passenger bus and a little more weight. Maintenance costs are higher, and some operators say the diesel engine's life expectancy is less than that of the gasoline engine.

However, the American diesel is unsurpassed in low fuel consumption and gives about 75% more mileage per gallon than a gasoline engine. This mpg represents a 43% saving in fuel consumption, which, added to the 11% saving in price per gallon of diesel fuel as compared with gasoline, aggregates nearly 50% saving in fuel cost per mile.

Such savings as these come from the higher thermal efficiency of the diesel engine's cycle because of higher compression ratios and from better part-load and idling economy.

Gasoline-engine compression pressures rarely exceed 140 psi, but in diesel pressure get up to 500 psi. This permits immensely greater ranges of useful air-fuel ratios for the diesel engine, making it far more economical at part-load operation, he said.

The speaker described in detail design refinements to better control of combustion, illustrated several precombustion chambers, and explained what had been done to improve the performance of various types of injector nozzles.

Prior to the technical meeting, which was presided over by Hans Hogeman, a chief engineer of American Bosch Corp., more than 100 members and guests inspected that company's plant at Springfield.

The technical session was preceded by a brief business meeting with Chairman David Waite at the helm.

Urges Motor Tune-Up Be Part of Routine

—F. G. WILDHAGEN, Field Editor

NORTHERN CALIFORNIA Section, Nov. 15—Motor tune-up should be a routine service procedure just like lubrication, fueling, and windshield washing—not an emergency measure to keep a broken-down engine in service or a remedy for specific ills, according to Carl Pape, manager, United Motor Service, Oakland, Calif.

Although he spoke principally of gasoline-fueled engines, he said the same ideas should be applied to butane, propane, and diesel engines.

Defining tune-up, he said that its function is to restore it to its original condition or to previously determined standards. These standards should be set by someone competent to consider the overall and long-term function of the vehicle. Maintenance supervisors should accept the results of the original engineering design for the specific class of vehicle in question and assume that a service procedure based on the manufacturer's recommendations is best. However, they may have to make adaptations for conditions such as ter-

rain, loading, and altitude that vary widely from the average.

Standards and variations should be tabulated for each type or class of equipment and be made readily available to the mechanic so that he can make proper settings and adjustments. Cut-and-try methods, although sometimes necessary, are wasteful, approximate, and generally unsatisfactory, he said.

After considering tune-up for compression, ignition, carburetion, and cooling, Pape said that the factors necessary to thorough, efficient tune-up are adequate tools and equipment, well-trained mechanics, and a definite procedure. He recommended that advantage be taken of service manuals and of courses offered by manufacturers and distributors of automotive equipment to acquaint mechanics with service problems.

Pape pointed out that the reduction of lost time and emergency breakdown alone will more than pay for the costs involved in tune-up and allow the owner to exercise more control over service lay-up time.

Section Inspects New GM Assembly Plant

—A. R. OKURO, Field Editor

NEW ENGLAND Section, Nov. 8—Feature of the meeting was a field trip to the new Buick-Oldsmobile-Pontiac assembly plant at Framingham, Mass., when more than 100 members and guests saw the newest assembly facility of the corporation about 20 miles from Boston.

The plant has more than 21 acres under roof, and buildings and equipment are of the most modern type.

Speaker of the evening session was Dean A. Fales, research associate at M.I.T., where the meeting was held.

Although he said that modern passenger car styling is a potent sales factor, the speaker held that since 1930 this trend had been detrimental to safety, comfort, and servicing.

Up to 1930 motor vehicle design had progressively improved vision, seating positions were erect, steering was fast, weight distribution was generally good with a 60 to 40 distribution, ground clearance was ample, and service and maintenance were reasonably easy.

His studies have shown that fatigue is the cause of most accidents. All of our senses suffer fatigue, and this effects the entire body. Fatigue impairs judgment and action.

Sight is the most important of our senses in regard to motion, and clear and uninterrupted vision is necessary for safety and comfort.

The speaker's analysis of present automobile design showed potential hazards in the highly ornate, shiny plastic and chromium-plated steering wheel, hub, horn control, and windshield trim directly in front of the driver.

Added to these visual disturbances is the sloping V windshield which reflects the instrument panel, steering wheel, transmission lever, shining windshield wipers, hood trim, and other ornaments.

The steeply sloping windshield often causes double vision, which creates an hypnotic effect on the driver when the car is in motion, and causes fatigue. V windshields tend to limit vision to the pane in front of the driver, and his eyes must refocus when the line of vision passes through the other pane. Hence, when tired, he does not bother with the other pane.

In rainy weather the sloping V windshield also reflects street lights and building illumination, which cause confusing reflections and blind spots. The new curved windshields add to these confusing reflections, the speaker said.

These windshields are not effectively cleaned by wipers, leaving large blind spots. Thick corner pillars are a potential hazard too, he said.

The low seating positions in current models place the driver near the high intensity of oncoming light beams, the steering wheel interferes with good vision, and the rear vision has been minimized, he pointed out.

Although he estimated that 85% of the motorists in this country are responsible citizens who try to do what is right, something like 30,000 people are killed in motor vehicle accidents each year—125,000 are permanently injured; 1,250,000 are injured, and the annual property damage bill is about $1¼ billion, he said.

Besides Fales, former chairmen of the Section who attended the meeting were Nielsen, Whitham, Johnson, Hawk, Hassey, Smith, and Gardner. Among the guests were students from M.I.T., Franklin Technical Institute, and Wentworth Institute.

Col. J. M. Colby shows slides while he addresses Lawrence Institute of Technology Student Branch on "Substitution of Horsepower for Manpower in Military Life"

Show Causes, Effects Of Engine Detonation

—RENE CUILLOU, Field Editor

HAWAII Section, Nov. 15—Detonation as an operating problem was described by Meredith Littlefield and Frank Elliott, Los Angeles, Ethyl Corp. engineers.

They demonstrated the causes and effects of this phenomenon by showing normal combustion and detonation of mixtures of ether and carbon tetrachloride in a glass tube.

Following their description of the process of combustion, a dynamometer test was made on Program Chairman John Rodger's automoble, which he had obligingly driven into the dining room for this demonstration.

Interest of the 100 members and guests ran high due to the shipping tie-up on West Coast ports, and the use of what Honoluluans call "strike gas" provided under emergency conditions by California refineries.

Contrasts between detonation and smooth operation on high octane fuel were like glimpses of an oasis to a thirsty traveler in the desert.

Oil Resources Now Held to be Larger

—R. M. HARMON, Field Editor

WICHITA Section Nov. 10—Our petroleum resources have been developed from 10 to 20 times faster than has been done in any other country, and as a result known reserve estimates run from 25 to 50 years, according to SAE President R. J. S. Pigott, who spoke on "Developments in Fuels, Lubricants and Lubrication" at the Lassen Hotel.

Therefore our entire fuel supply situation must be critically examined for the maximum efficiency of utilization, he said.

Often our fuels are not used to the best advantage. In stationary powerplants solid fuels could be used to stretch out the supply, he suggested, for the powerplants for vehicles and aircraft.

"We should design powerplants for solid fuels whenever possible, because the known reserves of coal are estimated at several hundred years," he said.

Increasing compression ratios and perfecting transmission designs will go

far to economize gasoline and diesel fuels, he pointed out.

Pigott presented the past-chairman's certificate to Harold Zipp.

Public's Needs Direct Passenger Car Trends

—F. G. WILDHAGEN, Field Editor

NORTHERN CALIFORNIA Section, Central Valley Meeting, Oct. 29—Automotive engineering development is shaped by the needs of the public, stated Harold T. Youngren, vice-president and director of engineering of the Ford Motor Co.

He proved his point with examples of developments that were good but failed because they were not needed by the public when they were introduced.

The 1910 Brush featured coil springs all the way around, but many years elapsed before independent front-wheel suspension was adopted generally. It was not until 1934 that several American manufacturers adopted the principle of independent wheel suspension. Primary reason for this delay was the lack of real need. Until then, there was no real need simply because motorists used their cars for comparatively short jaunts, and women—an increasingly important factor in passenger car design—weren't driving to any great extent.

Today an ever-mounting need for a better ride has the industry on its toes. And rides are going to get better.

Gear shifts followed the same pattern. The 1888 Benz and the 1903 Great Arrow had gearshift levers mounted on the steering columns. But designs were immature, and the wobble stick was more attractive from a simplicity and cost point of view.

Gradually, however, as the automobile proved its usefulness for running errands and for pleasure motoring, women became interested in driving. Whereas some men took pride in their ability to shift gears without clashing, women did not share their enthusiasm. The need for something simpler was born.

The result was the synchromesh transmission. And the need for more space in the front compartment sent the gearshift lever back to the steering column.

Members Watch Drama Of Making Stainless

—J. D. WAUGH, Field Editor

BALTIMORE Section, Nov. 11—Full membership turned out for an inspection today of the Rustless Division of Armco Steel Corp. here from the melt shop to the shipping department, and saw processing of bars, rods, strip, angles, channels and wire.

Divided into groups with experts for guides, the tour started in the melting department where electric furnaces were being charged with pigs, lime, and alloy bars. Pyrotechnics of furnace tapping and ingot molding followed, and the group saw the breakdown and later forming and finish rolling of stainless products which find their way into practically every industry.

Following the breakdown of glowing billets in the big rolling mill, bars went to the small mill where they were further reduced to specified sizes for customers. A 4-ft, 115-lb bar was reduced to a small square rod 30 ft long in 3 min. After reheating, shapes are again reduced to final dimensions and straightened.

Wire of 3/8-in. diameter was put though successively smaller dies and reduced to 1/16-in. A white lead-bearing coating is used to lubricate the dies, which are subjected to tremendous pressures and friction during this process. Some 2000 dies are on hand to meet the demands of various users.

Constant checking with micrometers was evident everywhere at this stage, and some of the small wire is again rolled into strip and other shapes. Pickling baths remove scale and restore the steel to its natural shimmering beauty.

In the centerless grinding department round rod from 1/8 to 4 in. in diameter is finished and cut into order lengths.

Great care in protecting workers was evident throughout the plant. Buck Rogers safety masks, safety shoes, asbestos gloves, safety aprons, and carefully designed guards on machines doubtless went far to achieve the posted 1063 days without a lost-time accident. Safety posters keep up a continual warning to the men.

Car Design Trends Described by Wolf

—R. G. SHANKLIN, Field Editor

MOHAWK-HUDSON Group, Nov. 10—Compromise between true engineering and cost of manufacture has always been the rule, rather than the exception, in the automotive industry due to the inevitable laws of economics, Austin M. Wolf, director of standards of New York State told a capacity audience of 80 members and guests.

"The passenger car of today represents this compromise perhaps to a more marked degree today than ever before in the industry's history," he said.

"Today's balance is more delicate because of the enormously increased materials and labor costs, public demand for better and more economical performance, increased driving comfort, and greater factors of safety versus the public's willingness to pay the price for these values," he pointed out.

He predicted that not before five years will the higher compression "Kettering" engine come into common use, the delay being mainly due to the economics of the petroleum industry.

"However," he said, "by means of overdrive or a fourth speed in addition to higher compression ratios, large fuel economies are now being realized."

Those features in current automobile design which make maintenance difficult and repairing expensive were decried by the speaker, but those designs had apparently come about by the public demand for more styling and willingness to pay a premium for maintenence.

Twenty members of the SAE Rensselaer Polytechnic Institute Student Branch, with Prof. Dale Brown, attended the meeting.

Tucker Seeks Loan To Launch New Car

—J. E. P. SULLIVAN, Field Editor

DAYTON Section, Oct. 27—Five hundred members and guests attended the Section's first dinner meeting of the season and heard Preston Tucker, president, Tucker Corp., Chicago, outline his plans to secure a loan of $30,-000,000 to put his factory in production.

He said he was on the point of getting into actual production when the plant was closed to permit a government investigation.

His program calls for a gradually accelerated production which in a year will rise to a car a minute on a two-shift operation.

Starting with Cadillac at 13, he has had experience with Ford Motor Co. and the late Harry Miller, Indianapolis designer and producer of racing cars. He said he conceived the idea of the Tucker automobile in 1927 while with Miller.

Chairman George W. Heck of the Section presided.

Demonstrates Tools of Stress Analysis

—L. D. WATKINS, Field Editor

MILWAUKEE Section, Nov. 5—William T. Bean, project engineer in charge of Stress Laboratory, Continental Aviation & Engineering Corp., an advocate of Stresscoat and horse sense, demonstrated their use with gadgets and slides.

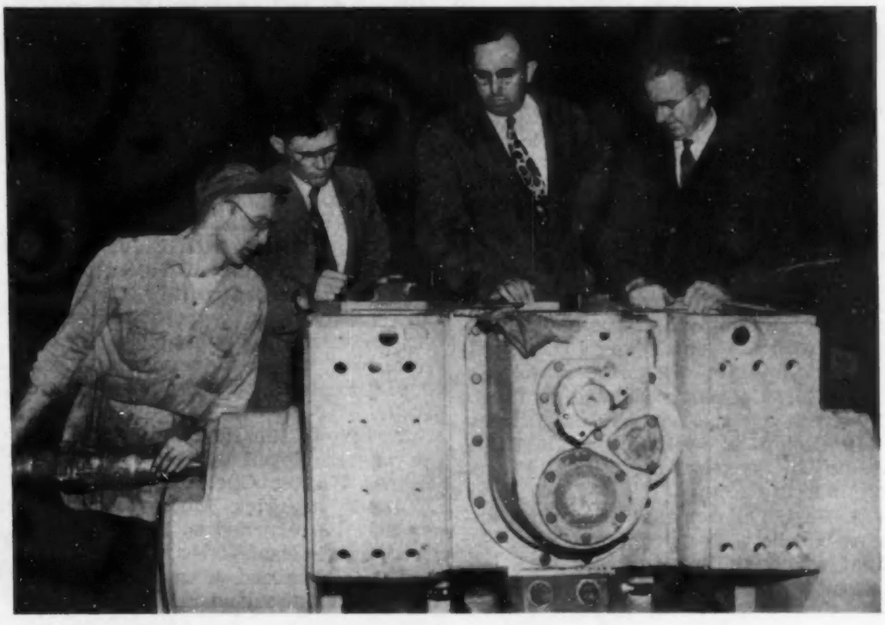
Comparing the newest Continental

Continued on p. 86

At dinner preceding President Pigott's talk at Texas Section are W. I. Truettner, left, C. H. Wetzel, Pigott, Section Chairman J. W. Walker, Hollister Moore of SAE staff, and M. C. Gibler

Innovation at Southern California Section meetings is giant-size name and company affiliation tag. Shown wearing their tags at the Transportation and Maintenance Meeting, Nov. 18, are Technical Chairman Cal Thomas, left, Jerry McBrearty, chief structural engineer for Lockheed Aircraft, Speaker John G. Holmstrom, of Kenworth Motor Truck, and Section Chairman Jim Sinclair

1947-1948 Detroit Section Chairman Bob Insley (left) receives a certificate of appreciation from Arthur Nutt at Detroit Section's Nov. 15 meeting



Before his address at Central Illinois Section, J. W. Symonds was taken on a tour of Allis-Chalmers tractor works at Springfield. Here Norman Hawley and Symonds, both of Peter Kiewit Sons' Co., and John T. Liggett, technical chairman for the meeting and assistant chief engineer at the plant, watch workman Charles Willoughby adjust the bevel gear and pinion in the steering clutch and final drive housing of a crawler tractor with a pneumatic nut tightener

Continued from p. 84

engine with older models, he exemplified the great advantages of stress analysis prior to the construction of experimental components. "It was often found," he said, "that removal, rather than addition of material, relieved high stress concentration." The use of strain gages augments that of Stresscoat and facilitates the correlation of results.

The new engine was thoroughly taken apart in the discussion and "before and after" photographs illustrated the technique used in the design and development of specific parts. The question and answer session, running far into the night, brought out much additional interesting information:

1. It is convenient to use Stresscoat in an air-conditioned room, but charts are available to predict the effect of temperature. Strain gages and extensometers are used for purposes of correlation.

2. Materials other than the one proposed for final use may be substituted for analysis so long as the modulus of elasticity is known. However, the specified material is preferred.

3. The speaker suggested, whimsically, that photoelasticity might be used to greater advantage for publicity purposes by the research department of an engine company than for actual design work.

4. Stresscoat, a more efficient tool for studying stress distribution, can evaluate compressive as well as tensile strains. In order to indicate compressive strains, the part is subjected to load for a couple of hours, during which time the Stresscoat relaxes to zero strain. When the load is removed, the cracks in the coating indicate compressive strains. Thus, in a way, the usual process is reversed.

5. Bean observed that the tools of experimental stress analysis do everything but "think". He has found no substitute for a brain.

6. The flat opposed engine is cooled by a fan normal to the plane of the cylinders. This fan cools not only the engine but also the engine oil and torque converter oil as well. When the engine is running at full load in stalled condition, cooling consumes approximately 10% of the horsepower.

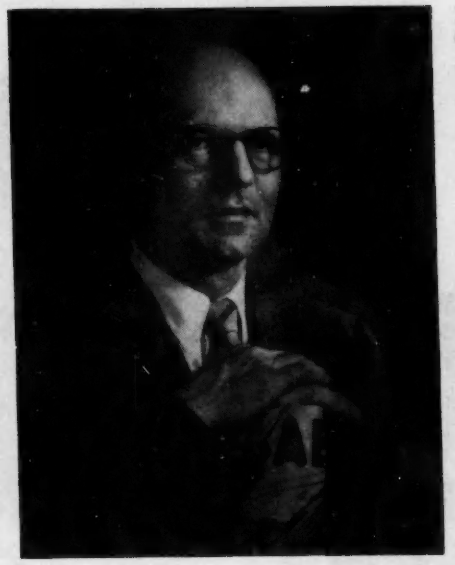
7. A crankshaft torsional vibration damper is used to eliminate troublesome vibration during the development period. A final analysis is made later, usually on the vehicle and either justifies or eliminates the damper.

8. The modern metallurgist, unlike his predecessor, is now inclined to question design as well as material, thus being of greater assistance to his engineering group.

9. Bean believes that the piston engine will be with us for some time and that although gas turbines and jets

Continued on p. 88

SAE Section



ROBERT H. CRAIG

CRAIG

. . . . of Mohawk-Hudson

Robert H. Craig knows automotive servicing and selling from the tires up. Now he is sales manager of the Passenger-Car Division of Albany Garage & Appliance Distributors, Inc., but he entered the field back in 1918 when he went from Albany High School to a job as mechanic's helper with the local Cadillac dealer.

The next year, he became a mechanic and a carburetor specialist for a repair shop that specialized in carburetor and tune-up work. In 1923, he took the position of tester with E. V. Stratton Motors, distributor of Hudson motor cars for northeastern New York State. In 1925 he was promoted to general service manager, having charge of both retail and wholesale service and parts departments, a position he held until 1928.

Moving to the New York City area, he was employed by Bates Chevrolet, Bronx; Kanter Chevrolet, Passaic, N. J.; and Bushwick Motors, Brooklyn. In 1932 he returned to E. V. Stratton Corp. as wholesale sales representative, and he remained with this concern until it was dissolved in January, 1939.

In February, 1939 he joined the Albany Garage, Dodge-Plymouth distributor, as assistant sales manager.

During the war, he served with the War Production Board as Automotive Specialist. In October, 1945 he returned to the Albany Garage and his present position.

Craig's interest in SAE began back when he was 23 and attended a SAE National Fuels and Lubricants Meeting in Chicago. He joined SAE in 1944 and was elected Secretary-Treasurer of the Mohawk-Hudson Group in 1946 and Vice-Chairman in 1947.

He is also a member of the Eastern New York Federation of Sales Executives and President of the Burden Lake Improvement Association.

His main interest, outside of his work and SAE, is in his new home at Burden Lake, where he finds plenty to do in his spare time between gardening, landscaping, and his home workshop. He is a firm believer in country living and practices what he preaches.

—R. G. Shanklin, Field Editor

WALKER

. . . . of Texas

Jim Walker often wonders how he got tangled up with a bunch of automotive engineers after he had his formal education in chemistry. Maybe it is because he has spent most of his time since 1930 in research and development in the fuels and lubricants field.

Jim has operated a consulting service for the past three years. Since starting the business, he has perfected a geochemical method for locating oil deposits by a study of shallow soil samples.

Hunting and fishing are high on the list of things he likes to do, but he doesn't find much time for participation in either. Any time he has left over from his consulting service is divided between his family and SAE. The family consists of his wife and two daughters, one daughter in high school and the other at Southern Methodist University.

Jim has served as Secretary and Treasurer of Texas Section and devotes a large portion of his time to the activities of the society.

—Floyd Patras, Field Editor

Chairmen

These biographies are part of the series on 1948 - 1949 Section Chairmen

G. ALLAN CREIGHTON

CREIGHTON

. . . . of Williamsport

G. Allan Creighton has had as much variety in his powerplant engineering experience as he has in his after-work interests.

For the past five years he has been in charge of the special problems section for engine component testing at Lycoming Division, AVCO Manufacturing Corp. Currently he is engaged in a survey analyzing available means for starting jet engines.

Al started his powerplant engineering work in the experimental and research laboratory of the Waukesha Motor Co. under Arthur Pope and Howard Wiles on development tests of the Waukesha Comet diesel and Hesselman engines.

In 1939 he went to the New London Ship and Engine Works of the Electric Boat Co. There he engaged in development testing of a new diesel engine for use in a coast-defense type submarine. He participated also in initial development tests of a solid-propellant torpedo tube for PT boats and served as assistant to the chief engineer in charge of sales and service.

One factor that started him on his engineering career was his contact with boats as a boy in New London, Conn. He moved there at an early age from Prince Albert, Saskatchewan, Canada. M.I.T. furnished his formal engineering education and granted him his degree in 1935.

Al is married and has two fine children, a boy and a girl. They live in the country, and Al goes back and forth to work in one of his two Crosley cars. One is reminded of the silent movie days to see Al and his family emerge from their car.

Creighton was one of the founders of the Williamsport Group four years ago and has been active ever since. Besides, he plays cello in the Williamsport Symphony Orchestra and sings tenor in the church choir.

Despite all these activities, he finds time to take care of a hive of bees which this year produced 14 gallons of honey.

—H. W. Epler, Field Editor

J. W. WALKER

WAITE

. . of Southern New England

Dave Waite's interest in automotive engineering is an offshoot from his interest in metallurgy.

He is a metallurgist and sales engineer for the Wallace Barnes Company in Bristol, Conn., makers of many of the springs that go into automotive accessories. He has been with them since 1927. His present work takes him through New England and the New York and Philadelphia metropolitan areas.

Before joining Barnes, he had been an assistant professor and consultant on chemistry and metallurgy at the University of Buffalo from 1920 to 1926. Between his teaching work and his graduation from Massachusetts Institute of Technology with the class of 1917, he had gained practical experience as a metallurgist for the American Steel & Wire Co. and the Wickwire Spencer Division in Worcester, Mass.

In 1919, he married Marjorie Seward of Worcester. They have one daughter, Marge Ann, and two granddaughters, Deborah and Molly, whose interests are his chief hobby.

A salt-water enthusiast—even to the point of taking a daily swim before breakfast—Dave glories in a new summer home at the Rhode Island shore. Besides family, new home, and SAE, he finds a lot of pleasure in gardening and golf.

—A. M. Watson, Field Editor

DAVID WAITE

Continued from p. 86

are being developed by everyone (including Continental), they are not ready to take over, on a commercial scale, the job of vehicle propulsion.

MacDonald Gives Beecroft Lecture

—J. T. DUCK, Field Editor

WASHINGTON Section, Nov. 16—The Second Annual David Beecroft Memorial Lecture was delivered here by Thomas H. MacDonald, U. S. Commissioner of Public Roads at the Mayflower Hotel.

The veteran public roads official received the award for his "outstanding contribution to highway safety in connection with his work in the Public Roads Administration." He has been in this field of engineering and administration for more than 30 years, beginning when there were only 12 miles of highway in the country built with Federal funds.

Toastmaster was Pyke Johnson, chairman of the Beecroft Traffic Safety Committee and president of the Automotive Safety Foundation.

Among the distinguished guests were SAE President R. J. S. Pigott, Past-President H. C. Dickinson, and Paul G. Hoffman, ECA administrator and first recipient of the award.

"Human behavior at the wheel, with foot on accelerator rather than the brake, is the all-important criterion for highway design," MacDonald told the meeting. H. W. Evans, Section chairman, presided.

The lecture appears in full on p. 41 in this issue of the SAE Journal.

Doman Advocates Aircooling Engines

—R. G. SHANKLIN, Field Editor

MOHAWK-HUDSON Group, Dec. 7—"I am thoroughly convinced that direct aircooling in internal-combustion piston engines is the most logical way to cool them," said Carl T. Doman, vice-president and chief engineer of Aircooled Motors, Inc., at a meeting held on the Union College campus at Schenectady.

"If we were better scientists or possibly better engineers," continued Doman, "we would obtain greater efficiency from our engines and thus practically eliminate our cooling problems."

However, he explained that there seems to be little hope of materially increasing our thermal efficiencies, despite what we hear about the Kettering high-compression or the Cadillac high-compression engines. In the final analysis, both incorporate no new features, but simply are able to use higher compression ratios due to the availability of better fuels.

Doman expressed the opinion that very few people understand the fundamentals of engine cooling, otherwise engines would be aircooled for all types of power. As it is, aircooled engines are comparatively rare.

As a firm believer in the practical application and efficiency of the aircooled engine, he emphasized that we must continue to break down the notion that aircooled engines overheat. Use of aircooled engines in the past war and the new line of Continental tank engines certainly are breaking down this idea, he said.

Doman granted that it would require millions of dollars to tool new lines of aircooled engines plus considerable money to train personnel in specialized service operations required by aircooled engines in place of the operations required by water-cooled engines, but he assured listeners that basically the aircooled powerplant should cost no more to produce than the liquid-cooled powerplant.

Backstage of Car Development Shown

—H. B. FRYE, Field Editor

CINCINNATI Section, Nov. 22—Insight into the vast research program on the car of the future was disclosed by H. S. Currier, chief engineer of the Ford Motor Co. passenger car department.

Some of the developments included these components that had been discarded over the years for one reason or other, but which appeared to have merit:

- Cars with rear engine drive,
- Rear engine front drive,
- Tubular backbone frame, one of which had transmission and chassis as a unit and hinged from the front end,
- Split rear axle hinged at differentials,
- Drives down tubular sections to each rear wheel,
- Plastic bodies,
- X, star, V, vertical, and aircooled engines, and
- Mr. Ford's last project—a five cylinder in-line engine.

The new Ford, the speaker said, was designed as a completely new car without force-fitting any units of previous models.

After detailing the design objectives

set up by top engineering management, Currier outlined the procedure of the "team" of departments, including stylists, which produced the new models.

Integrated frame and body produce a unit with best possible beam loading and torsional rigidity. The box section frame was selected to provide maximum torsional strength and result in a lower vehicle due to the relatively small cross-sectional depth, he pointed out.

Construction Equipment Needs Factory-Planned PM

CENTRAL ILLINOIS Section, Nov. 15—A strong plea for factory-planned preventive maintenance programs for construction equipment was voiced by J. W. Symonds, equipment superintendent of Peter Kiewit Sons' Co., contractors, at a meeting held in Springfield.

He urged builders of construction equipment to furnish users with a complete preventive maintenance program designed to secure maximum equipment life. He also encouraged equipment engineers to design for preventive maintenance adjustments.

The factory-planned preventive maintenance program should be outlined in clearly-worded, well-illustrated manuals covering all adjustments vital to perfect performance. Maintenance operations should be grouped in a few regular periods. The factory should supply visual aids such as wall charts, strip films, and slides for use in instructing maintenance personnel, Symonds added.

By designing for preventive maintenance, builders can take advantage of the longer life of adjustable-type members, he said. Adjustment methods on identical components used by several manufacturers should be standardized, to end the present confusion where different manufacturers prescribe varied lubrication and maintenance procedures.

Dealers might be encouraged to provide preventive maintenance service for individual owners who do not have adequate personnel or tools to do their own preventive maintenance work, he suggested.

A-C System Ups Generator Output

—J. E. TAYLOR and MURRAY FAHNESTOCK

PITTSBURGH Section, Nov. 23—An alternating-current generating system has been developed to meet the demand imposed by mobile two-way radio equipment for wide-speed-range, high-

output electric power systems for motor vehicles.

The system and some of the reasons for its design details were described by Albert D. Gilchrist, chief engineer of the Leece-Neville Co. He explained that wide speed range is a prerequisite for generators used on variable-speed engines.

Mechanical limitations on speed arise in securing the windings of the armature, design of the commutator, and selection of the bearings. Cooling is a problem at the low end of the speed range because airflow from the fan varies in direct proportion to speed.

Commutation is the main speed-limiting characteristic at high speed. Because reactance voltage varies directly with speed, d-c generators for low-speed performance (with high number of turns per coil) give short brush life at high speeds.

The alternator-rectifier system develops rated output of 60 amp at a much lower speed than the d-c system. The overall efficiency for the alternator-rectifier is about 50%, or slightly lower than for a d-c generator. The d-c system has a slightly lower cut-in speed, but the alternator-rectifier system shows a greater output over a much wider speed range.

One listener, whose company is considering purchasing a generator test bench, asked what capacity the test bench should have. Gilchrist replied that with the 150-amp alternators at 14 v now available, an 8-hp test bench would be required to cover full output.

However, he said, 5 hp should be adequate for low-speed checks, which are usually sufficient. These ratings are for rectifier output.

As to the practice of installing the rectifier in front of the radiator, the speaker reported that this was the installation recommended for the new Ford, although it is generally a costly practice. Main reason for mounting it there is that there is not room in the air stream in the engine compartment.

Ahead of the radiator, cooling is good, and trouble from dirt and water has been less than expected. Since the temperature of the rectifier is checked with thermocouples, it is sometimes safe to use a less desirable location if wire length and cost can be reduced.

A user of a-c systems on vehicles reported that his utilities company has been pleased with the performance of the units and is considering equipping passenger cars with heavy-duty generators capable of driving blowers for use in calibrating gas meters in the field.

Gilchrist warned that cost of such an application will be high unless the equipment is built in quantities.

STUDENT NEWS

Fenn College

SAE now has 3500 enrolled students in 25 branches and clubs, Dudley Higgins, manager of the student department of SAE, told the Fenn Student Branch on Nov. 10.

He explained operating procedures for student branches and benefits available to enrolled students. The SAE Placement Service, he reminded potential job seekers, serves enrolled students as well as other members of SAE.

—R. L. Pappas, Field Editor

Lawrence Institute of Technology

How the Army is developing a high degree of standardization to relieve the severe problem of front-line maintenance in combat was explained by Col. Joseph M. Colby, chief of the Development & Engineering Department, Detroit Arsenal on Oct. 29 before 120 students.

The number of spare parts for one unit has been decreased from 450,000 to 45,000 for field servicing, he reported in describing work under way in a

broad program to "substitute horsepower for manpower in military life."

The new aircooled engine developed for the Army Ordance Department with engineers of Continental Motors Corp. can be mounted vertically to save space, is easier to maintain and service, and develops more horsepower than those used in the last war although it is smaller, Colby reported.

University of Wisconsin

Dr. John T. Rettaliata, Illinois Institute of Technology, described the historical development of the gas turbine from the earliest attempts to modern installations.

One-time researcher on this type of powerplant with Allis-Chalmers Mfg. Co., and a consultant to the military services, the head of the mechanical engineering department at Illinois brought a wealth of information to the meeting.

The group has planned a tour of the Carnegie-Illinois plant at Gary, Ind.

—R. W. Henke, Field Editor

Massachusetts Institute of Technology

Futuristic drawings of stylists' ideas of 1959 followed a discussion of styling trends by Charles Jordon at the Oct. 21 meeting.

The sketches were conceived by designers at Buick Motor Division, GMC.

The speaker illustrated his talk with slides of the new Nash and Lincoln lines.

On Nov. 18, Edwin Crankshaw, assistant chief engineer of Cleveland Graphite Bronze Co. showed the M.I.T. Student Branch a moving picture outlining the manufacture and inspection of precision sleeve bearings and bushings.

Connecting-rod bearings, it was disclosed, are made from strip stock, formed in presses, and broached or reamed to size. Trimetal stock with a thin steel back, a layer of copper-lead alloy, and a final layer of babbit 0.001 in. thick, is plated with such accuracy that no final finishing operation is required.

—R. L. Parker, Field Editor

Oregon State College

A fuel of less than 7 psi Reid vapor pressure is best for light aircraft, Alf Hundere, research engineer of California Research Corp., told the Branch members.

This he concluded from flight tests employed to measure vapor locking tendencies, cylinder head temperatures, and general engine performance with different fuels.

The speaker also concluded that most pilots do not lean their air-fuel mixtures enough. To do this properly, there must be a definite head temperature for each setting.

Most pilots tend to climb their airplanes too steeply. Thus their air speeds are reduced and less air flows around the powerplant. This, he said, is the chief cause of excessive cylinder-head temperatures.

When flown at a lesser angle of attack, the engine runs cooler and engine life is increased, he said.

•

Inspection trips to the Cummins Diesel shops, the Burns Truck service shop, and the California Asphalt plant preceded the dinner meeting where the Branch members were guests of the Oregon Section.

The nation must become economy minded concerning our natural resources, according to President R. J. S. Pigott, the principal speaker.

Power wasted by incomplete expansion in internal combustion engines could be recovered, he thought, by use of aftercoolers in conjunction with intercoolers currently used.

Dual fuel carburetion is not far in the future, he predicted, and pointed out the new competition of gas turbines, particularly as prime movers for ground installations where plenty of room is available.

The discussion period was a lively closing to the meeting.

University of Illinois

Further development of air transportation depends on more airports and producing private aircraft with more utility, Dr. Leslie A. Bryan, director of the Institute of Aeronautics and a director of the Illinois Wing, C.A.P., told an audience of 80 members on Oct. 27.

"Air transport today can be compared with water transportation following the War of 1812, railroad development following the Civil War, and the automotive transport following World War I," he said, pointing out that there are today a half million pilots and many more airminded people in this country.

A full schedule of meetings has been planned for the remainder of the semester.

—J. R. Tucker, Field Editor

Parks College

Thirty-one student members and five members of Parks College of Aeronautical Technology saw a moving picture recording dispatching, loading and unloading, pickup, delivery, and maintenance operations of Slick Airways, Inc., the largest airfreight carrier in the world, on Nov. 9.

Jerry Miles, the company's district manager, and Maurice Knoche, sales manager of the new St. Louis office, disclosed that the line's 22 converted C-46 airplanes have been operating at a profit for the past few months. The potential business, they believe, is enormous in this field because more and more manufacturers will understand the value of speedy shipment of goods.

Employment prospects in this field were explained by the speakers, who envision rapid expansion in air freight operations.

The program started with a fried chicken dinner, and the meeting was started by Chairman Duane (Doc) Phillips of the Student Branch. Gene Kropf, head of the college's department of air transport, Registrar Edward Barker, chairman of the St. Louis Section Student Activity Committee, and Frank Myers, William Ryan and John Rauth, instructors, were present.

The following night, Nov. 11, the Student Branch presented the second in a series of Shell films on the petroleum industry. "The Birth of an Oilfield" described details of oil production from drilling the first well to delivery of crude to the refinery. Other films will follow to explain further steps of production of petroleum products.

New Members Qualified

These applicants qualified for admission to the Society between Nov. 10, 1948 and Dec. 10, 1948. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (Aff.) Affiliate; (SM) Service Member; (FM) Foreign Member.

British Columbia Group

Jack Charles Ames (A).

Buffalo Section

Daniel F. O'Donnell (J).

Canadian Section

Bruce John McColl (M), Harold Christie Purdy (J), J. S. Walker (A).

Central Illinois Section

Dale Leroy Richardson (M).

Chicago Section

Edwin Edward Dato (J), Waldemar J. Distler (A), Harold A. Doolittle (J),

Michael Joseph Dudas (J), Harry A. Hedland (M), J. L. Hipple (M), William Joseph Orr (A), Roy W. Roush, Jr. (J), Ralph Summerfield (M), Omer William Swaney, Jr. (J).

Cleveland Section

Chester D. Christie (M), Robert E. Harris (J), Alfred M. Hastert (J), Seymour Charles Himmel (J), Frank E. Rom (J), S. Blackwell Taylor (M), Donald P. Williams (M).

Colorado Group

Dwight I. Binkley (A).

Dayton Section

Robert George Lusian (J).

Detroit Section

Clay Patrick Bedford (M), Charles J. Benner (J), Conrad F. Bennett (A), John J. Bush (J), Edward M. Eberhart, Jr. (J), Sheldon G. Little (M), Duane Elvin Marquis (J), L. S. McCune (M), Albert O. Roberts, Jr. (J), A. D. Wagner (M), Thomas Jellison Wall (J).

Hawaii Section

Lloyd Dean Larson (A).

Indiana Section

Jerome Collins (J), Theodore C. Nolte (M).

Kansas City Section

George W. Forman (M).

Metropolitan Section

Troy P. Baughman (A), Franklin M. Cohn (J), Jack Ellis Cox (J), Emil Kameny (M), William W. McClintock (J), Walter J. Milani (J), Edward Stanly Miller (J), James P. Murray (A), Sydney Gwyer Tilden, Jr. (J), Henry Albert Weber (J), Henry Scherp Weston (A), Charles Wohl (J).

Milwaukee Section

Vet V. Holmes (J), Troels Warming (M).

Mohawk-Hudson Group

Kenneth I. Langwig (J).

New England Section

William A. Musculus (A), John Rosenberg (A).

Northern California Section

Thomas L. Craig (A), Tore Nelson Franzen (J), Jay Graves (A), William E. Kelley (A), Chester A. Kemp, Jr. (J).

Northwest Section

Brian Edward Boyle (J), Homer W. Keith (J).

Oregon Section

Del. G. Law (A).

Philadelphia Section

Charles S. Gilbert, Jr. (J). John A. Petho (M), Edwin P. Walsh (M), Wilbur F. Wilhelm, Jr. (J).

Pittsburgh Section

W. L. Kann (A), David Woodward (J).

San Diego Section

William George Gebhardt (J).

Southern California Section

William Henry Foland (M), Harry Glascock (M), John F. Kowalik (A), George W. McNeal, Jr. (J), Paul P. Mozley (M), Melvin Geo. Paul (A).

Southern New England Section

Robert H. Fraser (M), Morgan Jones (M), Tao-Wen Ma (J), Donald Hart Vetterlein (J).

Syracuse Section

Vincent J. Himrod (J).

Texas Section

Richard W. Hoyt (M), Artemon P. Johnston (J).

Outside of Section Territory

George William Fruth (J), Edgar R. Jordan (M), George E. Mason (M), Donald B. Olen (M), Robert H. Shenk (M), Victor Arthur Wegner (A).

Foreign

Dr. Ahmed Mounir El-Barbary (FM), Egypt; George F. Hill (FM), So. Amer.; Saim Kurem (FM), Turkey; Vernon Preston (J), England; Bernard Harry Riley (FM), France.

Applications Received

The applications for membership received between Nov. 10, 1948, and Dec. 10, 1948 are listed below.

Baltimore Section

Jethro Benjamin.

British Columbia Group

James Alexander Angus, Leslie Walter Garvin, Harry Holmes, George Arthur Lloyd, Fred Marrington, Thomas Walsh McKee.

Canadian Section

Clifford F. Graham, Allan R. M Millar, William L. D. Muir.

Central Illinois Section

John C. Eirk.

Chicago Section

Frank J. Acton, John R. Azola, Alfred G. Bartlett, Johnson S. Davis, Davis Mackay Gunn, Emil H. Hahn, Paul Paleczny, Eugene J. Polley, Norman N. Snyder, George L. Turner.

Cleveland Section

Henry Alfred Peller, Joe A. Wascavage.

Colorado Group

George R. Crandall, Frederick D. Wilson.

Dayton Section

William L. Tenney.

Detroit Section

Dominic Badalamente, George Arthur Brown, George W. Conover, Jr., William G. DeKam, Edward W. Hufnagle, James Jack, Edward T. Kantarian, Howard C. Kellogg, Uolevi L. Lahti, Gordon I. Lyman, Benjamin A. Main, Jr., Kenneth George Matthews, Donald H. McPherson, William Robert Smith, A. J. Steger, Thomas H. Terry, Lloyd R. Vivian, Jr., Ralph E. Williams, Clarence E. Wittmer.

Hawaii Section

Drury Adams.

Indiana Section

Reginald Carpenter Ferreira.

Kansas City Section

Donald Martin Crowley, Glover Lee Williams.

Metropolitan Section

William R. Beckerle, Leon I. Emerson, Miss Selma G. Gottlieb, L. E. Grubb, Frits Jonker, Charles Arnold Kalman, J. Lawrence Kess, Adolph Losick, Capt. Jose A. Wahnish.

Milwaukee Section

Charles L. Spraker.

Mid-Continent Section

Fred Champlin.

Mohawk-Hudson Group

Herbert Roy Jaffe, Clair L. Pepperd, Harry L. Ross.

New England Section
Benjamin R. Chase, Bernard F. Ford.

Northern California Section
Herman V. Boley, F. T. Brown, Clyde L. Davenport, Henry W. Larson, B. C. Mills, George I. Truckell.

Northwest Section
J. E. Cannon.

Oregon Section
R. J. O'Donnell, Jess J. Sitton, Harry D. Smith.

Philadelphia Section
Wilfred H. Bernard, John P. Casserly, George B. Hill, Herbert Klossner Livingston.

Pittsburgh Section
Edward G. Mosher.

St. Louis Section
William T. Huddle, Eugene S. Kropf, H. Stuart Litzsinger, T. V. Picraux.

Salt Lake City Group
W. P. Ackerman, Cliff H. Dunn.

Southern California Section
Ben D. Asher, Louis R. Cook, George S. Gervais, George F. Harkins, Richard R. Shade, Manton Leo Sheehan, Arthur H. Smith, Rhys O. Williams.

Spokane-Intermountain Section
Charles Howard Franklin.

Texas Section
Walter H. Hutchcraft, Jim Landers.

Washington Section
Albert Fleming Thompson, Robert Ernest Samuel Thompson.

Western Michigan Section
Robert W. Emelander.

Outside of Section Territory
Karl W. Galliger, Earnest R. Harrison, Johnnie Moran Lackey, John Emerson Lovely, A. A. Schnorr, Ralph A. Sherman, Franklin C. Walters, R. C. Zeller.

Foreign
John Roy Yorke Edwards, England; James John Gray, Sudan.

Change of Address

So that your SAE mail will reach you with the least possible delay please keep SAE Headquarters and the Secretary of your local Section or Group advised of any changes in your address. Such notices should be sent to:

1. Society of Automotive Engineers, Inc., 29 West 39th St., New York 18, N. Y.
2. The Secretary or Assistant Secretary of your Section or Group at the addresses listed below:

Baltimore
R. D. Taber, Koppers Co., Piston Ring Div., Bush & Hamburg Sts., Baltimore 3, Md.

Buffalo
Robert D. Best, Fredric Flader, Inc., 583 Division St., N. Tonawanda, N. Y.

Canadian
C. E. Phillips, Perfect Circle Co., Ltd., 175 Wicksteed Ave., Leaside, Ont., Can.

Central Illinois
K. J. Fleck, Caterpillar Tractor Co., Peoria, Ill.

Chicago
T. A. Scherger, Studebaker Corp., Main & Bronson Sts., South Bend 27, Ind.

Cincinnati
W. A. Kimsey, R. K. LeBlond Machine Tool Co., Madison Ave. & Edward Rd., Cincinnati 8, Ohio

Cleveland
(Miss) C. M. Hill, 7016 Euclid Ave., Cleveland 3, Ohio

Dayton
R. S. Goebel, Production Control Units, 901 Shroyer Rd., Dayton 9, Ohio

Detroit
(Mrs.) S. J. Duvall, Detroit Office, SAE, 100 Farnsworth Ave., Detroit 2, Mich.

Hawaii
E. G. McKibben, Pineapple Res. Inst., P.O. Box 3166, Honolulu 2, T. H.

Indiana
R. P. Atkinson, Allison Div., General Motors Corp., Indianapolis, Ind.

Kansas City
F. V. Olney, Gas Service Co., Kansas City Mo. Div., 842 Grand Ave., Kansas City 6, Mo.

Metropolitan
(Miss) J. A. McCormick, Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.

Mid-Continent
W. K. Randall, Carter Oil Co., P.O. Box 801, Tulsa, Okla.

Milwaukee
H. M. Wiles, Waukesha Motor Co., Waukesha, Wis.

New England
W. F. Hagenloch, Lenk, Inc., 1305 Boylston St., Boston 15, Mass.

Northern California
H. M. Hirvo, Enterprise Eng. & Fdy. Co., 600 Florida St., San Francisco 10, Calif.

Northwest
C. F. Naylor, Ethyl Corp., 1411 Fourth Ave., Seattle, Wash.

Oregon
Ray Mobley, Wentworth & Irwin, Inc., 1005 W. Burnside, Portland 9, Ore.

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HYATT'S Fifty-Seventh "Thank You" Note

AGAIN for the fifty-seventh year, all the folks at Hyatt say sincerely—"We thank you."

Here at Hyatt it is not our custom to think only of our customers at greeting time.

That "the customer is boss" is constantly kept before our four thousand workers every working day.

Witness the slogans, some of which are reproduced here, contributed by Hyatt. employees.

With this spirit prevailing, it is natural that every Hyatt man and woman is imbued with a desire to make Hyatt Roller Bearings precisely accurate, dependable and long-lasting.

Hyatt has a long and unequalled experience as specialists in roller bearings. Our design engineers, laboratory technicians, backed by modern machines, manned by skilled operators, show the way in serving old and new Hyatt friends.

You just can't stay in business as long as Hyatt has without always looking ahead and giving workers the highest quality materials and the most modern equipment with which to produce the finest grade of roller bearings.

Our objective for 1949, as always, is your complete satisfaction with Hyatt bearings and service. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey; Chicago; Detroit; Pittsburgh; and Oakland, California.

"THE CUSTOMER IS BOSS" SLOGAN SERIES

That The Customer Is Boss, Don't Just Know It---Show It!

...WARD QUINTON — DEPARTMENT 124

"THE CUSTOMER IS BOSS" SLOGAN SERIES

Our Business From Day To Day Depends On What The Customers Say

DANIEL McCARTHY — DEPT. 50, CLARK PLANT

"THE CUSTOMER IS BOSS" SLOGAN SERIES

If It's Not A Precision Product, The Customer "NO'S" It

EDWARD J. KOEHLER — DEPARTMENT ...

HYATT ROLLER BEARINGS

Philadelphia
Laurence Cooper, Autocar Co., Lancaster Ave., Ardmore, Pa.

Pittsburgh
J. E. Taylor, Gulf Research & Development Co., P. O. Drawer 2038, Pittsburgh 8, Pa.

St. Louis
R. T. Adolphson, Sunnen Products Co., 7910 Manchester, St. Louis 17, Mo.

San Diego
H. L. Stone, 1561 Catalina Blvd., San Diego, Calif.

Southern California
C. L. Fernau, Standard Oil Co. of Calif., 605 W. Olympic Blvd., Los Angeles 36, Calif.

Southern New England
C. O. Broders, Pratt & Whitney Aircraft Div., United Aircraft Corp., 400 Main St., E. Hartford, Conn.

Spokane-Intermountain
J. F. Conner, Auto Interurban Co., W. 508 Cataldo, Spokane, Wash.

Syracuse
W. F. Burrows, Aircooled Motors, Inc., Liverpool Rd., Syracuse 8, N. Y.

Texas
E. C. Steiner, OEM Industries, 301 N. Justin St., Dallas, Texas

Twin City
R. J. Strouse, Mack-Int'l Motor Truck Corp., 2505 University Ave., St. Paul 4, Minn.

Virginia
S. L. Baird, Fairfield Transit Co., R.F.D. 1, Sandston, Va.

Washington
H. A. Roberts, G. M. Roberts Brothers Co., 17th & U Sts., N. W., Washington 9, D. C.

Western Michigan
L. W. Kibbey, Sealed Power Corp., 500 Sanford, Muskegon Heights, Mich.

Wichita
M. L. Carter, Southwest Grease & Oil Co., Inc., 220 W. Waterman, Wichita 2, Kansas

GROUPS

British Columbia
Burdette Trout, Truck Parts & Equip., Ltd., 1095 Homer St., Vancouver, B. C., Can.

Colorado
S. G. Scott, Fenner Tubbs Co. 1000 E. Fifth Ave., Denver, Colo.

Mohawk-Hudson
Lester Anthony, Albany Transit Co., Inc., 135 Ontario St., Albany 5, N. Y.

Salt Lake
H. C. Slack, Fruehauf Trailer Co., 1082 S. Second W., Salt Lake City, Utah

Williamsport
J. W. Hospers, Lycoming Div. Avco Mfg. Corp., 1515 Park, Williamsport, Pa.